EXPLORING INDIVIDUAL AND ENVIRONMENTAL DETERMINANTS OF FOOD INTAKE

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BBehSci(Hons)

Submitted in fulfilment of the requirements for the degree of Doctor of Philosophy (Psychology) in the College of Health and Medicine, University of Tasmania,

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Declaration of Originality

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Statement of Ethical Conduct

The research associated with this thesis abides by the international and Australian codes on human and animal experimentation, the guidelines by the Australian Government's Office of the Gene Technology Regulator, and the rulings of the Safety, Ethics and Institutional Biosafety Committees of the University. Ethics approval for Chapter 2 was obtained from the Tasmanian Social Science Human Research Ethics Committee (reference number H0016081). Ethics approval for Chapters 3 and 4 was obtained from the Tasmanian Social Science Human Research Ethics Committee (reference number H0014439). Ethics approval for Chapter 5 was obtained from the Tasmanian Social Science Human Research Ethics Committee (reference number H0017015).

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List of Publications in this Thesis

Chapter 1

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Chapter 2

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Chapter 3

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Chapter 4

Elliston, K. G., Ferguson, S. G., Schüz, N., & Schüz, B. (2016). Situational Cues and Momentary Food Environment Predict Everyday Eating Behavior in Adults With Overweight and Obesity. *Health Psychology*. https://doi.org/10.1037/hea0000439

Chapter 5

Elliston, K. G., Schüz, B., Albion, T., & Ferguson, S. G. (2020). Comparison of Geographic Information System and Subjective Assessments of Momentary Food Environments as Predictors of Food Intake: An Ecological Momentary Assessment Study. *JMIR Mhealth Uhealth*, *8*(7), e15948. https://doi.org/10.2196/15948

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Elliston, K. G., Ferguson, S. G. & Schüz, B. (September 2019). Objective (GIS) and subjective food environment as predictors of momentary food intake. Oral presentation at the annual EHPS conference in Dubrovnik, Croatia.

Elliston, K. G., Schüz, B., & Ferguson, S. G. (August 2018). Daily goal conflict and adherence to dieting goals: An ecological momentary assessment study. Oral presentation at the annual EHPS conference in Galway, Ireland.

Abstract

Rates of overweight and obesity have increased worldwide over the past 30 years. This has directly led to an increase in health conditions such as hypertension, type 2 diabetes, heart disease and stroke. These health conditions pose significant risk to the individual and a huge financial burden on the community, making the need for evidence-based weight-control measures vital.

Weight gain is ultimately driven by excess energy intake and insufficient energy expenditure. One of the key behavioural determinants of this energy imbalance is discretionary food intake. Discretionary foods commonly referred to as “snacks”, are non-essential foods consumed outside of main meals. These foods are typically energy-dense and nutritionally-poor, and have been estimated to contribute, on average, one third of an individual’s daily energy intake.

The consumption of discretionary foods is believed to be driven by both motivated, intentional decisions (i.e., people making the decision to snack or not), and momentary (variable) factors within the environment. The interaction between motivational and momentary eating cues is important. However, previous research on eating has either focused on motivated behavioural goals or on lab-based manipulations of food cues, thereby missing the fluctuating environmental exposures that prompt food intake. The studies in this thesis use Ecological Momentary Assessment (EMA) methods to examine the determinants of discretionary food intake. Through the use of EMA, individuals are studied in naturalistic environments as they go about their daily lives, thereby improving ecological validity and allowing for examination of contextual cues related to eating. This, in conjunction with baseline assessments of individuals’ dietary motivations, enable a greater understanding of the determinants of discretionary food intake.

Four complimentary studies were conducted with the aim to better understand the individual and contextual determinants of discretionary food intake. This thesis begins by examining how individuals prioritise and manage their dietary goals with other personal goals (Study 1, Chapter 2). In this study, dieters recorded their food and drink intake in real-time and provided a summary of engagement with their personal goals at the end of each day. The findings suggest that although daily food intake predicted long-term weight-loss, motivational determinants such as dieting goals and individuals' intentions may not be particularly important in guiding real-time eating decisions. Contextual factors need to be examined to better understand the how eating decisions are made in the moments leading up to food intake.

Study 2 (Chapter 3) examined discretionary food intake from an integrated perspective, using Temporal Self-Regulation Theory. Here, the interplay between individual motivations (i.e., self-regulatory capacity and behaviour pre-potency) and momentary cues (i.e., seeing others eat, experiencing negative affect and having food available) in shaping health behaviour self-regulation were explored. In this study, participants completed a baseline assessment of the motivations towards healthy eating and recorded their food intake in real-time using EMA methods. The findings showed discretionary food intake is largely guided by momentary cues, and motivational-level factors are less important in the initiation of discretionary food consumption. Given this finding, dietary interventions should aim to target the momentary cues which are associated with discretionary food intake.

Study 3 (Chapter 4) further examines the momentary cues guiding eating. Cues such as negative affect, the presence and availability of food and the presence of others eating were explored. Study 3 focused specifically on the momentary food environment shaping real-time eating decisions among people with overweight and obesity. Participants reported their food intake and exposure to environmental cues using EMA methods. The findings suggest contextual cues are associated with both main meal and discretionary food intake, and perceptions of the food environment influence food choice. Therefore, dietary interventions should combine individuals' healthy eating intentions and momentary cues with environmental-level interventions targeting the placement of food outlets.

Study 4 (Chapter 5) built on the results from Chapter 4 to examine discretionary food intake from the influence of the community nutrition environment. In this study, participants recorded their food intake and reported on the number and type of food outlets nearby in-real time using an EMA approach. Alongside participants reports, their electronic diaries recorded their GPS coordinates. GPS coordinates were overlaid onto a map of food outlets to produce an objective count of the number of food outlets surrounding an individual. Although further research is needed, the results suggest that subjective reports of the food environment predict eating better than objectively measured food environments. This is an important finding, as it suggests mHealth apps offering dietary advice may need to consider the type of food outlets rather than the raw number of food outlets near an individual.

Chapter 6 explores the common determinants and consequences of snacking and how we can best apply interventions to modify discretionary food intake. Across the research in this thesis, momentary factors were more predictive of discretionary food intake than motivational-level factors, highlighting the need for dietary interventions to address the environments that people consume food in. Momentary cue interventions include mHealth apps which can tailor dietary information based on an individual's location. The first two studies in this thesis expand the knowledge on motivational cues of eating by examining how personal goals and self-regulatory ability are associated with food intake. Additionally, by investigating contextual cues through both self-report (Chapter 4) and passively-collected GPS data (Chapter 5), new targets for mHealth dietary interventions are developed. Overall, the studies demonstrate how individual-level motivations and momentary factors within the immediate environment prompt real-time eating decisions, ultimately generating an evidence-based direction for dietary interventions aimed at reducing the burden of overweight and obesity and associated health conditions.

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Abbreviations

Abbreviation	Definition
ABS	Australian Bureau of Statistics
AIHW	Australian Institute of Health and Welfare
ANOVA	Analysis of Variance
AUC-ROC	Area under curve of the receiver operating characteristic curve
AUD	Australian Dollars
BCT	Behaviour Change Techniques
BMI	Body Mass Index
CI	Confidence Interval
CSIRO	Commonwealth Scientific and Industrial Research Organisation
EAT	Eating Attitudes Test
EMA	Ecological Momentary Assessment
GIS	Geographic Information System
GPS	Global Positioning System
ICC	Intraclass Correlation Coefficient
mHealth	Mobile Health
MLR	Maximum Likelihood Ratio
NHMRC	National Health and Medical Research Council
OR	Odds Ratio
SD	Standard Deviation
SE	Standard Error
SMS	Short Message Service
TPB	Theory of Planned Behaviour
TST	Temporal Self-Regulation Theory
WHO	World Health Organization

Chapter 1 Introduction[1]

[1] Extracts of this chapter has been published: Ferguson, S. G., Jahnel, T., Elliston, K. G., & Shiffman, S. (2020). Ambulatory Assessment. In A. Wright & M. Hallquist (Eds.), *The Cambridge Handbook of Research Methods in Clinical Psychology* (pp. 301-311). Cambridge University Press. https://doi.org/10.1017/9781316995808.029 (see Appendix 1.1 for the publication).

In the paper by Ferguson et al. (2020), I contributed to planning, writing and editing the entire manuscript, and took the lead on drafting the following sections; *Adopting Ambulatory Assessment methods for the study of psychopathology, Therapeutic uses of Ambulatory Assessment, and Utilizing real-time data in interventions: Promise, Problems and Future Directions*. The sections on *Using Ecological Momentary Assessment to understand eating behaviour* and *A move towards developing mHealth apps to change behaviou*r expanded on below in the introduction (Sections 1.6 and 1.7.2) of this thesis are modified from the publication.

1.1 Overweight, obesity and health

Across the globe, rates of overweight and obesity are increasing (Finucane et al., 2011). Over the past 30 years, the prevalence of obesity has more than doubled (World Health Organisation: WHO, 2016) jumping from 27.5% in 1980 to 47.1% in 2013 (Ng et al., 2014). Currently, there are 2 billion adults with overweight or obesity worldwide (WHO, 2016). In Australia– the context of where this research is conducted– around 12.5 million adults, approximately 67% of the adult population, have overweight or obesity; 36% overweight and 31% obese (Australian Bureau of Statistics: ABS, 2018). Overweight and obesity contribute 7.0% of the total health burden in Australia (Australian Institute of Health and Welfare: AIHW, 2017), the direct economic cost associated with obesity in Australia is $3.8 billion (in 2014/15 dollars; PwC Australia, 2015). With such high costs to the population, addressing excess weight is a public health priority.

Individuals are considered overweight or obese when they carry a level of body fat which may adversely affect their health (WHO, 2016). Overweight and obesity is commonly determined based on an individual's Body Mass Index (BMI), which is calculated using height and weight information (BMI= kg/m^2 WHO, 2016). A BMI >18.5 and <25 falls within the healthy weight range (overweight BMI ranges from 25-29.99, obese BMI $\geq$ 30: WHO, 2016). Although the BMI calculation was originally developed to assess what 'an average man looks like' (Blackburn & Jacobs, 2014), it is generally considered a good indication for an individual's level of body fat (Deurenberg & Yap, 1999). BMI levels are strongly associated with the risk of developing health conditions associated with excess weight (WHO, 2019). The higher an individual's BMI, the higher their risk of hypertension, type 2 diabetes, heart disease, stroke, respiratory problems, various cancers and many other diseases (AIHW, 2016b). Despite this, BMI has been criticised for not taking into consideration individual differences in weight; for example, BMI calculations do not account for differences in body type relating to muscle mass, age or gender (Deurenberg & Yap, 1999).

Although using BMI to assess an individual's weight status is a contested issue (O'Neill, 2015), it is still the most commonly used way of assessing an individual's weight (WHO, 2019). Alternative approaches include using body fat estimates, waist circumference, waist to hip ratio and skinfold thickness (O'Neill, 2015); each fraught with their own challenges. BMI is one of the quickest and least intrusive methods of assessing individuals' weight status and it allows for simple comparisons between individuals. Throughout the studies included in this thesis, BMI will be adopted to assess individuals weight status and be used to compare group differences in eating patterns.

1.2 Discretionary food intake and health: An overview

Weight gain is ultimately driven by an imbalance between excess energy intake and insufficient energy expenditure (Hill & Peters, 1998). One of the key behavioural determinants of this energy imbalance is food intake, in particular the intake of discretionary foods (Hampl et al., 2003). Discretionary foods— more commonly referred to as snacks— are foods which are consumed outside of the main meals of breakfast, lunch and dinner (Rangan et al., 2009). Discretionary foods typically include ultra-processed, energy-dense, nutritionally-poor food items such as biscuits, confectionary, pastries and alcohol (Cleobury & Tapper, 2014; Rangan et al., 2009; Watson et al., 2016). In accordance with the literature, the terms 'discretionary foods' and 'snacks' will be used interchangeably throughout this thesis.

In Australia, approximately one third of any individual's daily energy intake results from discretionary food consumption (ABS, 2015; Rangan et al., 2009). The prevalence, frequency and energy gained from snack foods has been steadily increasing over time (Fayet-Moore et al., 2017; Zizza et al., 2001). Among children, those consuming four or more snacks has almost tripled from 7% in 1995 to approximately 19% in 2011/12 (Fayet-Moore et al., 2017). Similarly, in the United States, the energy gained per snacking occasion has increased by 26% from 1977/78 to 1994/96 among young adults (Zizza et al., 2001). This demonstrates an increase in discretionary food consumption and therefore daily energy intake across various age groups.

The Australian Dietary Guidelines (2013) recommend individuals consume a variety of food across the five food groups each day (NHMRC, 2013). The five food groups include vegetables and legumes/beans; fruit; grains; lean meats; and milk products and/or their alternatives (National Health and Medical Research Council: NHMRC, 2013). Despite this recommendation, (Hendrie et al., 2016) reports that Australians' diets generally exceed the recommendations for discretionary foods. Australians typically eat 2.7 serves of discretionary food each day (Hendrie et al., 2016). Alcohol, sugar-sweetened beverages, confectionary, cakes and biscuits are the most commonly consumed discretionary items (Fayet-Moore et al., 2017; Hendrie et al., 2016). Among the Australian states and territories, Tasmania and the Northern Territory have the highest number of discretionary food consumption (Hendrie et al., 2016). In Tasmania— where this research is conducted— the average weekly serves of discretionary food is 20.5; above the national average of 19.15 (Hendrie et al., 2016). Ultra-processed discretionary food consumption is associated with a range of adverse health outcomes such as overweight, obesity, cardio-metabolic risks, cancer and type 2 diabetes (Elizabeth et al., 2020). Due to the health risks associated with ultra-processed food consumption, understanding the changes contributing to increased snacking is necessary in working towards ways to improve individuals' health. This thesis will examine the determinants underlying discretionary food intake, an essential step towards the development of effective dietary interventions.

1.3 Differences between the decision to eat and type of food consumed

Traditionally, the decision to eat has been considered to be driven by internal physiological processes such as hunger (Cornell et al., 1988). This "homeostatic hunger" results from a physiological lack of nutrients; prompting an individual to eat in order to replenish their energy (Lutter & Nestler, 2009; Saper et al., 2002). More recently however, research has examined how the pleasure derived from food intake encourages further food consumption (Lee & Dixon, 2017). This pleasure-driven "hedonic hunger" is thought be to prompted by psychological rather than physiological needs (Lowe & Butryn, 2007). When experiencing hedonic hunger, an individual's situation initiates feelings of hunger, rather than a physiological need to gain energy (Lowe & Butryn, 2007).

After an individual makes the decision to eat, they must then decide what foods to consume. Some studies suggest the number of daily eating occasions has increased over the past 30 years (e.g., Kachurak et al., 2018). However, other studies suggest there have also been changes in the types of foods individuals are consuming. For example, individuals seem to be increasingly reliant on processed, take away foods, rather than home cooked meals, and the use of oils and sugar-sweetened beverages are now commonplace in individuals' diets (Popkin et al., 2012).

Silventoinen et al. (2004) suggest rates of overweight and obesity in China and Australia have increased almost exclusively as the result of increased fat intake. Indeed, Barclay and Brand-Miller (2011) found that in Australia, individuals overconsume fast food products, but have reduced their total sugar intake over the past 30 years, suggesting that fat rather than sugar intake may be contributing to the increases in obesity. In the United States, this pattern is slightly different; larger portion sizes and higher eating and drinking frequency appears to be more related to the increase in rates of overweight and obesity than changes in micronutrient intake (Duffey & Popkin, 2011). Despite the differences between countries in population-level eating decisions and type of food, the food environment is a major component shaping individuals' energy intake and expenditure requirements (Romieu et al., 2017). Examination of the theoretical explanations surrounding eating decisions and food type is therefore necessary to better understand and potentially modify individuals' energy intake.

1.4 Theoretical explanations of food intake

Theoretical accounts of eating explain food-related behaviours as a result of conscious decisions or as a result of being exposed to contextual influences. Theories such as The Theory of Planned Behaviour (Ajzen, 1991) and Goal Conflict Theory (Stroebe, Mensink, et al., 2008), explore eating form a motivational perspective, where food intake results from individual-level traits and motivations, such whether or not an individual has the intention to eat, and what types of foods they should eat. In contrast, Stimulus-control models (e.g., Schüz, Bower, et al., 2015; Sobik et al., 2005) emphasise momentary cues, such as the situations and circumstances surrounding individuals as being more influential in driving food intake than individual-level motivations. Throughout this thesis, individual and contextual determinants underlying eating are explored through examining both motivational and momentary levels of influence on food intake. A socio-ecological model based off Dahlgren and Whitehead's (1991) rainbow model of health behaviour, is used to illustrate the levels of individual and contextual determinants of discretionary food intake (see Figure 1.1, below).

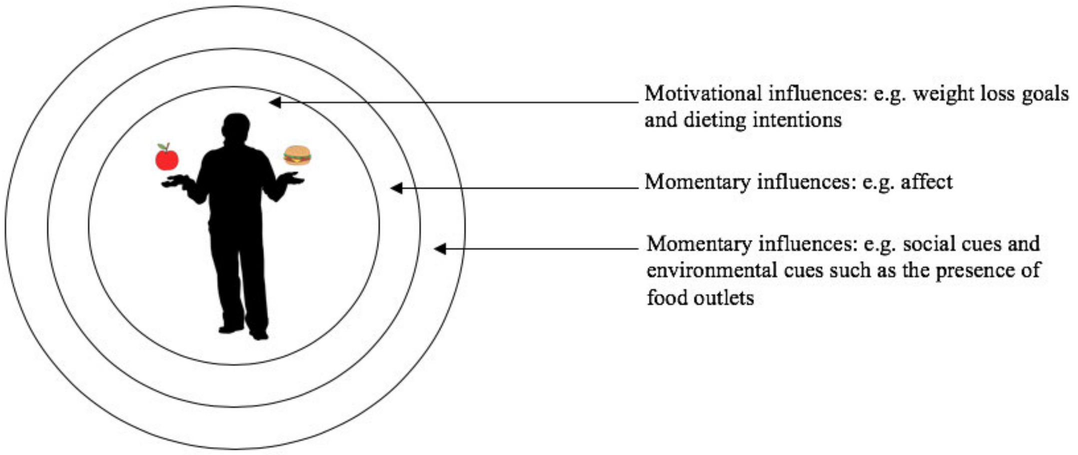

Figure 1.1 Diagram outlining the levels of influence for discretionary food intake that will be explored in this thesis.

Note: closer to the individual are motivational influences, which tend to be relatively stable and are driven by an individual's cognitions. Further away are momentary influences subject to greater fluctuation. These include an individual's affect (middle ring) and environmental determinants, such as the presence of food outlets (outer ring). Affect is represented in the middle ring as it is both driven by individuals' cognitions, but is subject to change depending on the situation and environment an individual finds themselves in.

1.4.1 Motivational predictors of food intake

The Theory of Planned Behaviour (TPB: Ajzen, 1991), outlines behaviour as being driven by intentions and then also specifies the factors that are important for intention formation. For example, how much effort an individual is willing to put into achieving a desired behaviour (Ajzen, 1991). Additionally, the TPB suggests that perceived behavioural control (i.e., how much influence an individual believes they have over their behaviour) moderates the relationship between their intentions and behaviour. When an individual perceives themselves to have high levels of control over their behaviour, their intentions are likely to translate into behavioural engagement (Ajzen, 1991).

The TPB is particularly useful for investigating the cognitive determinants underlying dietary behaviours (Baranowski et al., 2003). The TPB is can be applied to explain the antecedents leading to goal-directed behaviours, such as how having the intention to maintain a healthy diet motivates individuals to consume healthy food choices. Previous systematic reviews and meta-analyses (e.g., McDermott et al., 2015; McDermott et al., 2016) have found that constructs within the TPB have medium to large associations with both intentions and dietary intake.

Although the TPB is able to predict current behaviour, it is not necessarily able to predict if, and when, someone will change their behaviour. The utility of the TPB to create healthy dietary interventions may therefore be limited. Furthermore, it is likely that individual characteristics moderate the associations within the TPB. For example, perceived behavioural control has been found to be more strongly associated with behaviour among younger compared to older individuals (McDermott et al., 2015), suggesting age impacts the relationships within the TPB. Additionally, the TPB does not explain situations where individuals have limited control over their behaviour. For example, there may be some situations where healthy foods are not available, thereby healthy eating goals cannot be achieved. Individual characteristics such as self-regulatory ability is likely to supress engagement in undesired behaviours during such times.

Self-regulation is an individual’s capacity for altering their behaviour to bring it in line with their goals (Baumeister & Vohs, 2007). Self-regulation strategies include behavioural monitoring, goal setting and activity scheduling to facilitate ease of behavioural performance and rewarding oneself for achieving behavioural goals (Saelens et al., 2000). Previous studies have found that treatment-induced improvement in self-regulation is associated with improvements in healthy eating and weight loss (e.g., Annesi et al., 2016; Teixeira et al., 2015). Both self-regulation and intention fall within the motivational influences of eating and are examples of intrapersonal determinants which will be explored in Section 1.5.1 below.

Goal conflict theory (Stroebe, 2002) further explores the role of self-regulation in shaping individuals' health behaviours. Here, goals reflect the future states an individual wants to achieve (Kruglanski et al., 2002). However, in order to achieve success with personal goals, individuals need to balance their goals with the demands of numerous competing interests in everyday life. In terms of dieting and weight loss, maintaining healthy eating goals can be particularly challenging in food-rich environments, where palatable food is widely available. In food-rich environments, individuals are faced with many temptations to eat; rendering excess energy intake relatively easy to achieve and weight control difficult (Papies & Stroebe, 2012; Stroebe, Mensink, et al., 2008). Examining the pursuit of individuals' goals is an important step in understanding how goals are prioritised and managed (Presseau et al., 2013). In this thesis, Study 1 explores how motivational influences shape an individual's food choice through examining how individuals negotiate their dieting goals on a day-to-day basis.

Lastly, motivational influences surrounding eating encompasses past behaviours, namely individuals' habits. Eating, particularly the consumption of main meals, is largely driven by habit. Main meal consumption is consistently exhibited at the same time and in similar environments across days; individuals consume main meals without much conscious consideration. They can therefore be initiated by automatic behaviours (Aarts et al., 1998). For example, eating the same cereal for breakfast each day is a habit-driven behaviour. Breaking habits as a form of dietary intervention is the focus of recent dietary research (e.g., Adriaanse, Gollwitzer, et al., 2011; Beeken et al., 2017; Holland et al., 2006). A recent habit-based eating intervention found that asking individuals to do something different in their daily lives can break a habit and result in clinically significant weight loss at 12-months follow-up (Cleo et al., 2018), suggesting that targeting habits may be a way to change health behaviours.

Although motivational theories account for individual differences in food intake and choice, they do not adequately account for the contextual factors such as interpersonal and environmental cues believed to influence behaviour (for a further description of contextual cues associated with food intake see Sections 1.5.2-1.5.6). Contextual cues guiding eating have the potential to become automated habits if the cues are continually paired with food consumption (Grenard et al., 2013). Therefore, theoretical approaches to understand eating need to consider more momentary or contextual, influences which prompt food intake.

1.4.2 Momentary predictors of food intake

Momentary theories (e.g., stimulus-control models: Grenard et al., 2013; Schüz, Bower, et al., 2015; Sobik et al., 2005) suggest eating— particularly discretionary food intake— is determined by contextual cues prompting individuals towards consuming certain foods. This stimulus-driven eating involves the automatic processing of external cues (King, 2013), where contextual factors such as food availability (Cleobury & Tapper, 2014; McKee et al., 2014) and social norms (Prinsen et al., 2013; Vartanian et al., 2017) shape individuals' food choices. Importantly, these stimulus-control models suggest that external cues prompt individuals to crave— and subsequently consume— food irrespective of their hunger level.

Similar to motivational predictors, the influence of momentary predictors on discretionary food intake is subject to significant individual differences. For example, some individuals may be prompted to consume discretionary foods when they are feeling stressed, whilst others may be more likely to consume discretionary foods when others around them are eating (Sections 1.5.1 and 1.5.2 below describe the intrapersonal and interpersonal determinants underlying food intake). Additionally, the influence of momentary cues on eating fluctuates within individuals over time. Individuals are exposed to numerous contexts throughout each day. For example, an individual may move between numerous environments each day, from home to work, to the supermarket and then home again. Different cues will be present in each environment (see Sections 1.5.3-1.5.6 for a discussion of various environmental determinants of discretionary food intake). Therefore, consideration of both between and within-individual differences is necessary to understand the role of momentary cues on discretionary food consumption.

1.4.3 Combining both motivational and momentary approaches to eating

Despite the different theories examining dietary intake, research to date has neglected to combine both motivational and momentary influences to eating. There may be situations where one approach is more relevant than others. For example, for individuals who are dieting, their food choice is more likely to be driven by motivational factors as they are consciously trying to change their eating behaviour. In other situations, for example, being in a food-rich environment, food choice may be initiated by environmental temptations such as the sight or smell of food which override an individual's dietary intentions. Combining both motivational and momentary aspects of eating allows one to examine which influences are most relevant to the situations and contexts individuals find themselves in.

Temporal Self-Regulation Theory (TST: Hall & Fong, 2007) is one theory which combines both the motivational and momentary decisions shaping health behaviours. However, its application to discretionary food intake is lacking. In TST, behaviour is considered to be driven by both motivations (deliberate intentions surrounding whether or not to engage in a behaviour), and momentary cues (the contexts and environments that trigger behaviours). Furthermore, TST considers the temporal aspects of behavioural contingencies, thereby allowing for a greater understanding of why individuals engage in health-risk behaviours that have known detrimental long-term effects (Cameron, 2010).

According to TST, behaviours that lead to instant hedonic benefit are more tempting than behaviours that require self-control but result in greater long-term advantage (Cameron, 2010; Hall & Fong, 2007; Sallis, 2010). In terms of food intake, frequent discretionary food intake is associated with increased BMI and health-related conditions such as type 2 diabetes and high blood pressure (AIHW, 2016a). Despite these known health risks, discretionary food consumption is increasing (Fayet-Moore et al., 2017; Zizza et al., 2001).

Following the temporal aspects of behavioural contingencies outlined in TST, unhealthy eating is likely to have perceived short-term benefits, such as enabling an individual to indulge in highly palatable food and feel satisfied. Whilst the benefits of unhealthy eating may be immediately apparent, the costs associated with unhealthy eating do not appear for some time. The long-term consequences for unhealthy eating may result in individuals slowly gaining weight and potentially developing high blood pressure and diabetes in the long-term. Given that the immediate benefits of unhealthy eating occur closer to when the decision to eat is made, the immediate benefits are more tempting and outweigh the more distal costs (Hall & Fong, 2007), thereby leading individuals to consume unhealthy food despite knowing the long-term health risks. In this thesis, Study 2 will explore the relationship between the perceiving a cost of healthy eating occurring before eating and snack consumption.

In summary, this section has outlined motivational and momentary perspectives underlying the decision to eat and has highlighted the importance of combining both approaches. Section 1.5 below, further outlines the individual and contextual determinants of food intake which will be explored throughout this thesis.

1.5 Determinants of food intake

1.5.1 Intrapersonal determinants of discretionary food intake

Both research and popular opinion suggest affect is associated with changes in eating patterns (Conner et al., 1999; Wouters et al., 2017). However, the exact nature of this association is unclear. Some studies (e.g., Conner et al., 1999; O'Connor et al., 2008; Oliver et al., 2000) suggest that experiencing negative affect leads to increased food intake. Conner et al. (1999) for example, studied individuals' experience of daily hassles and found the number of hassles was correlated with the number of snacks consumed. In particular, the experience of daily hassles has been associated with increased consumption of high fat and sugary snacks (e.g., O'Connor et al., 2008). However, other studies (e.g., Bongers et al., 2013; Evers et al., 2013), suggest eating is associated with experiences of positive affect. Bongers et al. (2013) for example, used a short film to manipulate participants' mood and subsequently assessed their milkshake consumption. Bongers et al. (2013) found emotional eaters consumed more of the milkshake during a film designed to induce positive affect than they did during a negative affect induction. Methodological differences in the studies as well as individual characteristics such as personality, eating style, BMI and gender are likely to impact on the affect-snacking relationship (Conner et al., 1999; Wouters et al., 2017). This section further explores the role of affect on food intake.

Negative affect refers to negative emotional states such as anxiety, stress and boredom (Wouters et al., 2017). For some individuals, negative affect is a trigger for eating, often termed 'comfort eating' (Gibson, 2012). In this sense, individuals try to avoid or control their experience of negative affect through eating (Fox et al., 2017;

Heatherson & Baumeister, 1991). Typically, comfort eating involves consuming highly palatable foods, in particular, sweet and/or fatty foods (Gibson, 2012). Eating to improve one's mood is more common among females than men (Gibson, 2012). In the short-term, comfort eating may be reflective of an attempt to prolong mood improvement and escape from negative rumination (Gibson, 2012). Over the long-term, however, eating in response to internal stressors is likely to lead to increased body weight, especially among those who experience chronic stressors (Fox et al., 2017).

Some groups of individuals, such as restrained eaters— i.e., those who are chronically dieting— and individuals with overweight and obesity, are particularly vulnerable to increasing their food intake in response to negative emotional states (Cleobury & Tapper, 2014; Evers et al., 2018; Fox et al., 2017). It is not just the quantity of food intake that changes following negative emotional experiences, the type of food an individual consumes also changes. Oliver et al. (2000) suggests that snack food consumption is more susceptible to influences related to affect than the intake of main meals. When consuming main meals and healthy snacks, hunger and time of day are key drivers of eating (Cleobury & Tapper, 2014). In contrast, when experiencing negative affect individuals tend to consume unhealthy, high-energy items such as chocolates, cakes, biscuits and ice cream compared to when they feel more positive (Oliver et al., 2000).

Despite an emphasis on the role of emotions guiding eating over the last few decades, research has generally examined the relationship between negative affect and eating (Evers et al., 2013). Although popular opinion suggests the association between affect and eating is that unhealthy foods are tastier, and can have more of a mood boosting effect than healthy food intake (Raghunathan et al., 2006), Wahl et al. (2017) found that eating happiness of discretionary foods was no different than the eating happiness following healthier food items such as fruit and vegetables. Instead, they found that the greatest momentary happiness was associated with vegetable intake, suggesting that food may be a strategy to regulate well-being.

Positive affect refers to the emotional experience of feelings such as happiness and contentment; emotions which are likely to lead to pleasurable or desirable consequences (Wouters et al., 2017). In a meta-analysis by Evers et al. (2018), positive affect was associated with increased eating among restrained eaters, individuals with overweight and obesity, and individuals with eating disorders. Further, in a laboratory study of individuals within the healthy weight range, Evers et al. (2013) found that experimentally-induced positive affect resulted in an intake of 100kcal more food. As will be discussed later in Section 1.8, laboratory-based studies have been criticised for their lack of ecological validity.

An additional concern relating to laboratory studies involves the transient effect of affect manipulations on eating. Bongers et al. (2013) found that overeating occurred during the emotional experience; not afterwards, thereby suggesting that laboratory-based emotional manipulations may have only very short-term effects on individuals' food intake. It is possible that the association between positive affect and increased food intake is a result of individuals focusing on the hedonic pleasure gained from consuming certain foods (Evers et al., 2013).

This section has outlined how affect alters food intake (refer to Table 1.1 for a summary of the determinants surrounding food intake). Snacking is particularly vulnerable to internal determinants such as affect compared to main meal intake. Nevertheless, research has shown conflicting effects of the role of affect on eating. Despite the inconsistencies in the research, it is likely that individual characteristics such as gender, one's eating style and BMI all influence the affect-eating relationship. It is possible that other factors external to the individual play a role in the regulation of food intake. Section 1.5.2 will explore the role of interpersonal determinants in guiding discretionary food intake.

1.5.2 Interpersonal determinants of discretionary food intake

The eating behaviours of others influence individuals' food intake. Observing others eat can serve as a social norm; where individuals adjust their consumption to those around them (Herman et al., 2003; Higgs, 2015). Typically, individuals will eat more if their eating companion eats more (Herman et al., 2003), and match their food choice to their companion's intake (Hermans et al., 2009). This modelling food intake off others provides individuals with an indication of what is an appropriate amount to eat (Herman & Polivy, 2005). According to a review by Cruwys et al. (2014), social modelling has been consistently shown to occur when an individual aspires to be like their eating companion, or when an individual perceives themselves to be similar to their eating companion in terms of their age, sex or weight.

Social modelling can serve as an anchor by demonstrating an acceptable quantity of food to consume. Importantly, however, anchoring food intake off others is dependent on individuals' perceptions relating to the body type of their eating companion (McFerran et al., 2010). For example, when eating with an individual who is overweight, individuals typically consume less food than the overweight individual. Perhaps this is a result of an effort to avoid weight-gain themselves. Conversely, when eating with an individual who is underweight or within the healthy weight range, food portion is matched to the eating companion. In this scenario, the fear of gaining excess weight may be less prevalent as individuals are not directly confronted by it (McFerran et al., 2010). Social cues can therefore prompt momentary decisions surrounding appropriate food quantity.

When eating with others, both the quantity and the type of food consumed is influenced by social modelling (Higgs, 2015). For example, individuals tend to choose snacks which are consistent with the choices of others (Prinsen et al., 2013). In a study by Kaisari and Higgs (2015), female dyads completed a written distractor task while having access to high energy snacks. They found that participants modelled the number of snacks consumed off others regardless of whether their dyadic partner was familiar to them or not. This was the case even when participants had access to different snacks than their dyadic partner. Kaisari and Higgs (2015) note, that it is possible that such laboratory-based settings present such an unfamiliar environment that all participants—regardless of whether they were familiar or unfamiliar— looked to each other to guide appropriate food intake. Nevertheless, modelling food intake off others appears at least partially to be the result of an effort to conform with others and avoid being perceived as eating excessively.

Contextual cues such as the presence or the absence of others eating can create norms guiding appropriate food intake. A study conducted by researchers in our lab examined momentary fluctuations in situation-specific norm perceptions shaping eating practices (Schüz et al., 2018). Using Ecological Momentary Assessment (EMA) methods (discussed in detail in Section 1.6, below), individuals recorded their food intake and reported information relating to their social context (i.e., the presence or the absence of others, whether others were eating or not, and the perceived acceptability and encouragement of others to eat) over a 14-day period. Schüz et al. (2018) found that the presence of others increased the likelihood of eating, by changing the perceived appropriateness to eat and shifting perceptions relating to injunctive norms regarding the acceptability and encouragement of others to eat.

Social norms can override individuals' internal eating cues. For example, the influence of others eating can override subjective hunger levels (Herman et al., 2003;

Vartanian et al., 2017). In a recent study by Vartanian et al. (2017), participants were deprived of food for 18-hours and were exposed to various food consumption norms. They found that those who were exposed to a low-intake norm consumed less food than those who were not exposed to a consumption norm, suggesting the consumption norms shaped participants' food intake beyond their hunger levels.

Importantly, the effect of social cues on shaping food intake appears to occur without individuals being consciously aware that they are changing their behaviour based on others. Vartanian et al. (2008) examined individuals' explanations regarding their food intake. They conducted a laboratory-based study on female undergraduate students, where participants were grouped into pairs with incidental access to energy-dense food and were asked to watch television and report on what factors influenced their eating behaviour. They found that despite eating a similar amount to their partner, few participants reported being influenced by their dyadic partner's eating behaviour, suggesting the effects of social modelling of food intake may operate outside an individual's awareness.

Social modelling effects are found to occur even when models are not directly present. Environmental cues which suggest others have eaten are sufficient to nudge people to conform with a modelling effect (e.g., Mollen et al., 2013; Prinsen et al., 2013; Robinson et al., 2013). For example, displaying empty food wrappers has been demonstrated to steer individuals' decisions surrounding food choice and intake (Prinsen et al., 2013). In a study by Prinsen et al. (2013), a bowl with chocolates was left at the counter of a store, they manipulated the presence or absence of chocolate wrappers next to the bowl. When presented with empty chocolate wrappers next to the bowl of chocolates, participants ate significantly more chocolates than they did when no wrappers were present, thereby indicating their food intake was modelled off external cues (Prinsen et al., 2013). Given that social norms are such a powerful guide underlying food choice, it is possible that intentionally creating norms may nudge individuals towards healthier food choices (Higgs et al., 2019; Mollen et al., 2013).

Conversely, when individuals eat alone and are not exposed to social eating cues, their dietary intake tends to be less enjoyable and less healthy (Bellisle & Dalix, 2001; Reicks et al., 2019). However, it is possible that social facilitation on eating can be produced when individuals eat alone. In a study by Nakata and Kawai (2017), participants ate popcorn whilst sitting in front of different reflective surfaces. They found that those who ate the popcorn in front of a mirror (and could therefore see their own reflection), ate more and enjoyed the popcorn more than those who ate in front of a wall-reflecting monitor. This suggests that social modelling effects does not necessarily depend on the presence of others; the visual "presence" of another person is sufficient to change food intake and eating perceptions.

In summary, this section has examined the interpersonal factors underlying discretionary food intake. Seeing others eat provides a guide for an appropriate amount and type of food to eat. This social modelling effect is particularly relevant when individuals are in uncertain situations or aspire to be like their eating companion. However, individual characteristics such as body type and weight can alter the influence of social modelling and anchoring of food intake. It is believed that social norms shaping food intake are so pervasive they can override internal eating cues such as hunger. Overall, the effects of social modelling on food intake appear to operate outside an individual's awareness and can remain influential even when others are not physically present (refer to Table 1.1 for a summary of the interpersonal determinants surrounding food intake).

1.5.3 Environmental determinants of dietary behaviours

Social changes occurring over the past 40 years have contributed to the development of an ‘obesogenic’ environment; an environment promoting high energy intake and a sedentary lifestyle; factors associated with weight gain and obesity (Cohen, 2008; Lake & Townshend, 2006; Swinburn & Egger, 2002; Swinburn et al., 2011). A shift towards the mass production of food has made food more available and cheaper than ever before (Hill & Peters, 1998). Alongside this, the need to engage in physical activity has decreased; technology has largely taken over what were traditionally physically laborious jobs (Cohen, 2008). These environmental changes provide individuals the opportunity to consume plenty of food, but limits their ability to ‘work it off’, resulting in a society where excess energy intake and weight gain is the norm (Hill & Peters, 1998).

The built environment through its design, transportation systems and land use are key factors which influence community health (Lake & Townshend, 2006). In terms of environmental design, a lack of access to recreational facilities, and streets without footpaths are associated with low rates of physical activity (Giles-Corti et al., 2003). Limited access to recreational facilities in the neighbourhood such as greenspace, parks and outdoor play areas in conjunction with a lack of footpaths, means residents are less able to participate in physical activity, thus leading to an under expenditure of energy and the development of weight gain. Similarly, neighbourhood transportation systems influence individuals’ participation in physical activity; neighbourhoods which necessitate the use of driving instead of walking have higher rates of overweight and obesity than walkable or cycle-friendly cities (Frank et al., 2004). The environmental contributors to energy-intake is further explored in this thesis in Sections 1.5.4, 1.5.5 and 1.5.6 and is a focus of Chapter 4.

1.5.4 The nutrition environment

As highlighted in Section 1.5.3, the environment is increasingly becoming 'obesogenic'; changes in the environment over the past 40 years have coincided alongside increasing rates of overweight and obesity (Hill & Peters, 1998; Swinburn et al., 2011). Aspects of the environment such as the nutrition environment, influences an individual's discretionary food choice and is therefore a focus of the overall thesis.

The nutrition environment is an aspect of the local environment which encompasses the type and location of food outlets, their accessibility and their product availability (Glanz et al., 2005; see Figure 1.2). The nutrition environment is a major contributor to changes in obesity rates in the United Sates and indeed the rest of the world (Glanz et al., 2005; Hill & Peters, 1998). Over the past 40 years individuals are increasingly relying on eating out (Seguin et al., 2016), so the proportion of energy intake obtained from food outlets outside of the home environment is becoming increasingly important. Over this time, Australia has seen a rapid expansion of the number of take away and fast food outlets (Murray, 2018). Australian households now spend an average of $75 per week eating out; $44 at restaurants, hotels and clubs, and $31 per week on fast foods and take away (ABS, 2017).

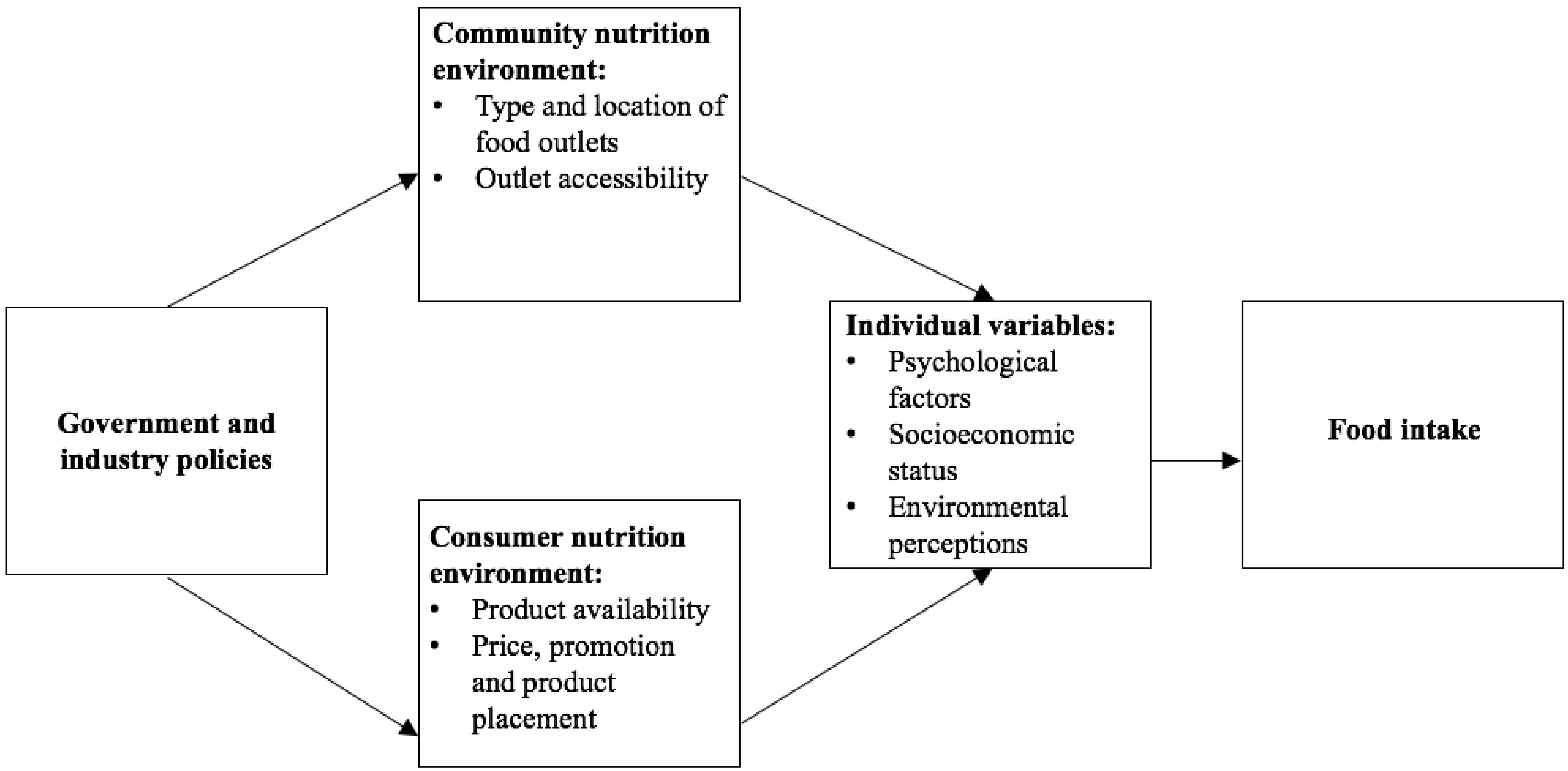

Figure 1.2 Conceptual model of the nutrition environment adapted from (Glanz et al., 2005)

1.5.5 The community nutrition environment

The community nutrition environment encompasses the type and location of food outlets available to individuals in the community (Glanz et al., 2005). Depending on what food outlets exist within the neighbourhood, individuals are presented with opportunities to eat (or not) (Caballero, 2007). The presence of food outlets within neighbourhoods are related to the health of the residents (Morland et al., 2006). For example, research from the United States and Canada has found that neighbourhoods with greater numbers of fast food outlets have higher rates of overweight and obesity than neighbourhoods with fewer or no fast food outlets (e.g., Fuzhong et al., 2009; Kestens et al., 2012; Morland et al., 2006). Kestens et al. (2012), for example, used travel survey data to examine exposure to food stores to predict overweight among participants. They found higher rates of exposure to fast food outlets were associated with higher risk of being overweight, suggesting individuals' food outlet exposures can explain some area-level variations in weight status.

In many western countries, there is a social gradient to the food outlet exposures individuals experience. Within Australia, residents from the most economically disadvantaged neighbourhoods have greater exposure of fast food outlets than those living in wealthier suburbs (Reidpath et al., 2002). This also seems to affect individuals' BMI; women living in areas of most disadvantage have, on average, a 1.08kg/m^2 higher BMI than those living in more advantaged neighbourhoods (men's BMI is .93kg/m^2 higher; King et al., 2006). It is difficult to separate whether individuals from lower socioeconomic neighbourhoods drive greater demand for fast food outlets compared to individuals of higher socioeconomic status, or whether fast food outlets target low-income areas to sell their products (Reidpath et al., 2002). Nevertheless, the community nutrition environment seems to shape residents' food choice and may also impact upon their weight status.

Residents who live in healthy community nutrition environments, defined as having access to supermarkets and grocery stores within the local environment (Glanz & Yaroch, 2004), not only have greater access to healthy foods, but seem to also have healthier diets (Story et al., 2008). Studies from both America and Australia suggest that individuals who live in areas from the highest tertile rank of healthy food environment are less likely to buy fast food than individuals who have poorer access to healthy choices (e.g., Fuzhong et al., 2009; Thornton & Kavanagh, 2012). Indeed, having a grocery store within the neighbourhood— that is, within one mile of participants' residential blocks— was found to be associated with 0.69 more daily servings of fruit and vegetables compared to individuals who do not have a grocery store nearby (Zenk et al., 2009). Furthermore, higher neighbourhood density of supermarkets is associated with lower rates of overweight and obesity (Morland et al., 2006). Together, this research suggests the community nutrition environment shapes the diet quality of residents living within the community.

Although certain food outlets may be available within the community, they may not be accessible to individuals. Rose et al. (2010) suggest research investigating the role of the environment on food intake should use multidimensional assessments (e.g., Geographic Information System-based measures of food outlets to individuals, and in-store assessments of food product availability) to determine the accessibility of food outlets within one's environment. Such assessment would enable a more in-depth understanding of the type of products that are available for purchase. Furthermore, aspects such as the outlets' opening hours and physical accessibility features such as the capacity for drive-through also influence food purchasing behaviour (Glanz et al., 2005). For example, access to grocery stores is diminished in the late night/early morning, resulting in certain groups of individuals, namely, shift workers, being unable to access healthier food outlets due to their work schedule being incompatible with store opening hours (Widener et al., 2017). The accessibility of food outlets can therefore shape food purchases regardless of the availability of nearby food outlets.

The community nutrition environment generally refers to the number and type of food outlets (both stores and restaurants) within close proximity to an individual. However, other sources of food places may be relevant features of the community nutrition environment, such as the home environment, schools and workplaces (Glanz et al., 2005). The home food environment for example, is associated with fruit and vegetable intake among youths. Previous research has found that having healthy food available within the home is associated with an increase in healthy food consumption (Ding et al., 2012). Similarly, the availability of healthy foods and parental encouragement of fruit and vegetable consumption is associated with healthier diet quality among children (Couch et al., 2014). However, permissive parenting practices such as not having food restrictions within the home and having unhealthy foods readily available are adversely related to dietary intake and children's weight status (Couch et al., 2014). These findings illustrate the importance of having a healthy home food environment on diet quality.

One aspect of the community nutrition environment that has received much attention from researchers and policy makers in recent years is that of the school environment (e.g., He et al., 2012; Ni Mhurchu et al., 2013; Thornton et al., 2016). Thornton et al. (2016) examined the presence of fast food restaurants around Australian schools by area-level disadvantage. They found schools in the most disadvantaged areas, defined using the 2011 Socioeconomic Index for Areas, had more fast food restaurants nearby than schools which fell within more affluent neighbourhoods. This may have implications on children and adolescents' fast food intake, as having fast food outlets located within 1km of a school is associated with a higher likelihood of fast food purchasing (He et al., 2012). The nutrition environment surrounding schools can therefore impede upon children and adolescents' dietary health.

In terms of adults' food intake, the community nutrition environment surrounding workplaces provide individuals with more exposure to food outlets and therefore opportunities to eat, than the environment surrounding one's home (Burgoine & Monsivais, 2013). In a study in Finland by Raulio et al. (2010), 30% of adults were found to eat their lunch at a workplace canteen, and less than half of adults brought their lunch to work, suggesting the availability of food both within and around the workplace can shape adults' food intake. As such, healthy eating interventions have turned to workplaces as a possible environment to target health behaviour change. For example, French et al. (2001) found that reducing the cost of low-fat foods for sale in workplace vending machines was associated with an increase in their sales. The availability and price of food products influence individuals' food purchasing and intake decisions.

In summary, there is a relationship between the health and BMI of a community and the presence of food outlets within the local neighbourhood region. This remains the case when looking at the type of food outlets around schools and the availability of food both within and around workplaces. However, even when outlets may be present in the environment, it does not necessarily mean they are accessible to everyone; factors such as store opening hours shape food purchases regardless of the availability food outlets. The next section explores environmental exposures to food inside and nearby retail food outlets.

1.5.6 The consumer nutrition environment

The consumer nutrition environment, on the other hand, refers to what consumers encounter when either inside or near a retail food outlet (Glanz et al., 2005). Features in the consumer environment such as the availability, price and advertising of products can serve as a cue to purchase and subsequently consume certain foods (Ni Mhurchu et al., 2013; Nestle & Jacobson, 2000). For example, increasing the shelf space dedicated to specific brands or sales, and moving items into more prominent locations (e.g., at the end of aisles) increases their sales (Glanz et al., 2012). In an American study by Payne and Niculescu (2018), a healthy eating intervention was rolled out into grocery stores whereby small fruit and vegetable packs were placed at end of aisle displays and staff suggested to consumers to purchase these fruit and vegetable packs. The stores included in the intervention, increased their sales of fruit and vegetables during the intervention period. Interestingly, overall consumer expenditure remained the same as it was prior to the intervention, suggesting that consumers switched some of their purchases to include the fruit and vegetable packs (Payne & Niculescu, 2018). Manipulating in-store environments may be a way to encourage individuals to consume healthier products.

In-store design has been the focus of marketing-based research (e.g., Chandon et al., 2009; Hawkes, 2008; Larson, 2006). Supermarkets and other food retailers are specifically designed to encourage shoppers to walk through the entire store (Larson, 2006), and product placement is aimed to maximise sales and influence an individual's food choice (Dixon et al., 2006; Larson, 2006). Typically, discretionary items such as chocolate, crisps, soft drinks and confectionary comprise the most prominent display of foods at checkouts and at end of aisle displays; grabbing shoppers' attention to make last minute impulse purchases (Thornton et al., 2012). Impulse purchases are generally more unhealthy than planned purchases and are greatly influenced by within-store displays and promotions (Crawford et al., 2007; Nederkoorn et al., 2009; Thornton et al., 2012).

Discretionary foods, in particular, are the result of impulse purchasing (Rose et al., 2009). In part, this is due to fresh food items such as fruit and vegetables requiring preparation and cooking before they are consumed, whereas discretionary foods can be consumed with minimal preparation and can therefore be bought as last-minute impulse decisions (Rose et al., 2009). In an Australian study by Crawford et al. (2007), women who planned their shops, cooked frequently, and enjoyed cooking were more likely to consume at least two servings of vegetables each day. In comparison, women who did not enjoy cooking, decided what to have for a meal last minute, and who frequently ate on the go, were less likely to consume two servings of vegetables each day, suggesting that planning shopping, cooking skills and enjoyment are related to daily fruit and vegetable intake.

Aside from in-store layout and design, other environmental cues such as product advertising can shape an individual's food choice. Research on nutrition has generally focused on how food-related advertisements can influence individuals to buy certain products (e.g., Boyland & Halford, 2013; Harris et al., 2009; Nestle et al., 1998; Nestle, 2002). For example, a recent systematic review and meta-analysis found children who are exposed to food advertising (on television and in videogames) consumed an average of 60kcal more than children who are not exposed to food-related advertisements (Russell et al., 2019). Exposure to food-related advertising may increase discretionary food consumption.

More recently, the advertising of nutrition information has been a focus of both research and public policy (e.g., Correa et al., 2019; Lawrence et al., 2018; Pulos & Leng, 2010; Wellard et al., 2015). Displaying the energy content of menu items on restaurant signage has been shown to alter consumers' food choice. For example, Pulos and Leng (2010) trialled a one-month display of nutrition information on the menus of some full-service restaurants in the United States and found the average entree sold after the labelling intervention contained fewer calories, fat and sodium then the entrees sold before the introduction of the nutrition labelling information. Additionally, customers reported ordering entrees based on the nutrition information presented on the menus (Pulos & Leng, 2010), indicating external cues such as menu labelling can nudge individuals towards healthier food choices.

In summary, this section has outlined how aspects of the food environment shapes momentary eating decisions. The consumer nutrition environment encompasses the outer ring in Figure 1.1, indicating momentary food cues external to the individual (refer to Table 1.1 for a summary of environmental determinants of food intake). Overall, numerous studies have found associations between the local food environment and discretionary food intake. However, exactly how these temptations in the environment shape real-time discretionary food purchases is not well understood. This thesis applies stimulus control models and Ecological Momentary Assessment to examine the predictors of real-time eating decisions.

Table 1.1 Determinants of food intake: Summary of cues prompting eating

Determinants	**Description**
Intrapersonal determinants	• Affect shapes eating decisions and food choice • Negative affect is associated with increased food intake (e.g., Conner et al., 1999) • Positive affect is associated with increased food intake (e.g., Bongers et al., 2013) • Methodological differences in studies may explain these contradictory findings and individual characteristics may influence the affect-eating relationship • This thesis will examine within-person fluctuations in intrapersonal determinants prompting food intake
Interpersonal determinants	• Seeing others eat creates norms surrounding food intake • Social modelling provides indication of appropriate amount of food intake (e.g., Higgs, 2015) • Individuals anchor their food intake based on the body type of their eating companion (McFerran et al., 2010) • Social modelling can occur even when others are not physically present, but there something in the environment indicates a social eating norm (Prinsen et al., 2013)

	• This thesis will examine the interpersonal determinants prompting food intake as individuals go about their daily lives
Environmental determinants	• Aspects of the environment prompt food intake • Having supermarkets close by is associated with healthier dietary intake (e.g., Thornton & Kavanagh, 2012) • The presence of fast food outlets is associated with higher rates of obesity (e.g., Morland et al., 2006) • Discretionary foods are placed in prominent locations in the supermarket to drive impulse purchasing (Rose et al., 2009) • This thesis examines momentary environmental exposures associated with discretionary food intake and how these change over time

1.6 Using Ecological Momentary Assessment to understand eating behaviour

This thesis will explore the real-world eating patterns both within and between people using Ecological Momentary Assessment (EMA: Shiffman, 2009) methods. EMA is best characterised as the repeated collected of data from individuals in real-time as they go about their daily lives (Shiffman et al., 2008). It involves individuals reporting behaviours of interest, such as eating, as well as their surrounding cognitions, emotions and situational factors that are believed to influence the initiation of these behaviours.

There are several features common in EMA approaches; firstly, EMA studies aim to capture behaviour in naturalistic settings, as individuals go about their daily lives (Shiffman et al., 2008). By collecting data in real-world environments, EMA captures the naturally occurring variations in individuals' experiences and contexts they are exposed to. This improves ecological validity and allows for greater generalization to individuals' real lives (Beckjord & Shiffman, 2014). Using this information, we are able to explore the links between individuals' behaviour and the situations and environments they are exposed to.

Secondly, assessments in EMA studies focus on individuals' current states and/or behaviours (Shiffman et al., 2008). If assessing individuals' current states/behaviours is not possible, assessments examine very recent states, experiences and behaviours. Previous studies have applied EMA to examine lapses in dieting behaviour (e.g., Carels et al., 2001; Goldstein et al., 2018). Through asking participants to report on the type of dietary lapse as well as the surrounding contextual information, such as their hunger level, tiredness, overall mood, environmental cues (e.g., presence of palatable foods), and time of day, Goldstein and colleagues were able to determine common triggers for dietary lapses and the types of lapses most associated with adverse weight outcomes. Asking individuals to report on behaviours and situations of interest close to the moment they occur eliminates the need for retrospective reporting, thereby reducing the biases associated with recall (Shiffman et al., 2008; Spook et al., 2013).

Thirdly, individuals in EMA studies complete multiple assessments over time (Shiffman et al., 2008). For example, Forman et al. (2017) investigated dietary lapse during a 12-month weight loss program, where participants completed three rounds of EMA monitoring; at baseline, mid-treatment and at the end of the program. Through the use of EMA, Forman and colleagues identified predictors of dietary lapse across various stages of a weight loss program, thereby identifying targets for future dietary interventions. Repeatedly assessing individuals over time allows for a greater understanding of behavioural experiences and how surrounding contexts fluctuate over time. Such information can also be used to assess the dynamic interplay between situations and environments triggering behaviours of interest (Beckjord & Shiffman, 2014).

Fourthly, EMA studies purposefully sample specific behaviours or times of interest (Shiffman et al., 2008). For example, previous EMA studies have focused assessments based on the initiation of events of interest (e.g., episodes of binge eating: Corstorphine et al., 2006; Sherwood et al., 2000), or examining individuals at various time points (e.g., periodically asking participants about their current emotions, hunger and binge status: Stein et al., 2007, or their food cravings: Richard et al., 2017). Often, EMA studies use a combination of these techniques to examine both the behaviours of interest and their surrounding contexts at various time points (e.g., Shiffman et al., 2014; Peacock et al., 2015; Smyth et al., 2007). This enables researchers to examine the role of internal (e.g., individual) and external (e.g., contexts and environments) cues underlying various behaviours. Below, I discuss the common sampling strategies used in EMA studies (see also Figure 1.3).

In EMA studies, moments in an individual's day can be sampled using event or time-based sampling techniques, or a combination of the two (Wheeler & Reis, 1991). Event-based sampling involves individuals reporting when a discrete event of interest occurs, for example, alcohol intake (Beckjord & Shiffman, 2014), binge eating (Smyth et al., 2007), food intake (Zenk et al., 2014), etc. Due to its focus on the initiation of an event, event-based sampling allows for an in-depth understanding of the experiences surrounding the event of interest. In the context of studies on eating, such as those explored within this thesis, event-based sampling involves assessments initiated by the intake of food; thereby enabling greater understanding of the experiences surrounding the food intake. Event-based assessments can be repeated over time, which allows researchers to track the occurrence of events and their sequences (Shiffman, 2009).

Figure 1.3 Types of sampling used in EMA studies.

Assessment type	**Characteristics**	**Key advantages**	**Key disadvantages**
Event-based	• Event of interest triggers the recording and assessment (e.g., consuming a snack)	• Allows a focus directly on the specific event of interest • Enables data collection on the context and situation around the time the event occurs • Allows for documenting behaviors and events that are occurring and their sequencing	• Difficult to estimate the true rate of events and thus difficult to determine non- – or biased – compliance with reporting • Potential for reactivity; the act of reporting means that an event has occurred which might influence future behavior
Time-based	• Scheduling assessments to sample participants' states over time (e.g., level of hunger present throughout the day)		

• Randomly scheduled*	• Randomly scheduled moments for assessment	• Easy test of compliance; calculate the number of assessments answered • Approximates representative and unbiased sample of moments within participants daily lives	• The unpredictable nature of when participants receive random assessments might be burdensome
• Fixed scheduled	• Fixed intervals (e.g., occurring every four hours) • Fixed periods (e.g., assessments in the morning and evening)	• Useful for cyclical temporal phenomena • Less intrusive for participants due to the predictable timing of assessments	• Crucial information at other times might be missed • Participants can anticipate assessments which might affect responses

*Randomly scheduled assessments may not necessarily occur at entirely “random” points throughout the day, instead they are timed to occur at “non-event”-based times (Ferguson et al., 2020).

There are some disadvantages associated with event-based sampling. Firstly, it is difficult to estimate compliance from event-based sampling. Individuals could choose to selectively report events believed to reflect favourably upon them. For example, individuals could choose to report food intake around the standard meal times of breakfast, lunch and dinner and not report meals which are consumed at more unusual times throughout the day. Furthermore, event-based sampling has the potential to induce a behavioural change, also known as reactivity (Cruise et al., 1996). It is possible that self-reporting of food intake could serve as a means of self-monitoring and thereby influence individuals to consume less food. However, previous EMA studies have found little support for reactivity caused by the protocol used in EMA monitoring (e.g., Stone et al., 2003 and see Barta, Tennen & Litt, 2012 for a discussion on measurement activity in diary research). Despite the challenges of event-based sampling, it is a useful technique for examining the everyday situations where events of interest occur.

Conversely, time-based sampling, involves assessing an individual's state and other relevant variables (e.g., their location, who they are with, and their current activities) at various type points throughout the day (Conner & Lehman, 2012). Importantly, and unlike event-based sampling, time-based sampling occurs regardless of what the individual is currently doing. As time-based sampling occurs independently of behaviours of interest, it is particularly useful for examining conditions that are not necessarily episodic in nature (e.g., fluctuations and level of craving experienced throughout the day).

There are two types of time-based sampling techniques commonly used in EMA studies; randomly scheduled and fixed scheduled assessments. Randomly scheduled assessments occur at various times throughout the day. Randomly timed assessments do not necessarily occur at entirely "random" points throughout the day, instead, they are timed to issue assessments at "non-event"-based times. These assessments can focus on factors such as individuals' cognitions and the environments they encounter throughout the day (Boh, Lemmens, et al., 2016; Campbell et al., 2018). As randomly scheduled assessments are not based on the occurrence of events of interest, they are useful for examining a variety of moments within individuals' daily lives and can provide a within-subjects case-control (Maclure & Mittleman, 2000).

Some determinants of eating, such as food-related cognitions are particularly suited to randomly scheduled assessments as they allow for the examination in cognitions leading up to events of interest. Recently, Boh, Jansen, et al. (2016) examined the eating-related cognitions and emotions among a sample comprising of individuals in the healthy weight range and in the overweight range. They found that across the sample, the majority of eating-related cognitions were related to the desire and anticipated taste of food. Furthermore, dysfunctional cognitions, such as knowing food is unhealthy but being unable to resist it, did not occur more frequently among those in the overweight range, suggesting dysfunctional cognitions do not play a major role in prompting food intake among individuals in the overweight range (Boh, Jansen, et al., 2016).

Unlike event-based sampling, calculating the compliance associated with randomly scheduled assessments is straightforward. Compliance is calculated by adding the number of answered assessments. Due to the nature of randomly scheduled assessments occurring at non-event-based times, they provide a more representative and unbiased sample of moments within an individual's day. Typically, EMA studies generate approximately five randomly scheduled assessments throughout the day (Shiffman, 2009). However, as the randomly scheduled assessments occur at unpredictable times, they are more burdensome for participants and care needs to be taken when designing EMA studies so that participants are not overly burdened with assessments.

On the other hand, fixed scheduled assessments occur at fixed time points throughout the day. For example, they could occur hourly, or be based at specific time points (e.g., in the evening). Fixed scheduled assessments focus on assessing behaviours, situations and experiences which occur at certain times throughout each day. They are particularly useful for examining the temporal dynamics underlying behaviours of interest. For example, Dunton et al. (2009) used fixed schedule assessments to examine the predictors of bouts in physical activity. As one strategy to encourage individuals to engage in physical activity is to build it into their daily routines, using fixed assessments is an appropriate scheduling type to assess if this works. In Dunton et al.'s (2009) study, participants were issued four assessments each day; one in morning, one at midday, one in the afternoon and one in the evening. They found that mood improved engagement in physical activity and having positive social interactions was associated with bouts of physical activity. Such findings may not have been possible without the use of repeated assessments at fixed time points.

In fixed scheduled assessments, individuals only need to reflect upon short periods of time, therefore errors associated with recall biases are minimised. By occurring at predictable times, participants know when they are going to be assessed and can prepare to answer a report, for example, by keeping a monitoring device on them around the time of the scheduled assessment. This is less disruptive than randomly-timed assessments. However, knowing when assessments are coming may result in participants modifying their responses based on their expectations of the study (i.e., participant bias) or they could be induced to behave differently because they know a report is coming up (i.e., they may experience reactivity). Nevertheless, fixed scheduled assessments allow researchers to identify changes within and across days and to assess how interruptions to individuals' schedules influence their behaviour.

Regardless of the assessment schedule, EMA uses multiple repeated assessments which enables for detailed information on within-person fluctuations in behaviours and situations of interest. By having individuals complete intensive repeated assessments over a few days or weeks, EMA allows researchers to examine how different contextual factors (social and situational factors), and internal events or states (e.g., mood) may change in the days, hours or even minutes, leading up to an event of interest, and how such antecedents alter the probability that behaviours such as eating will occur (Maclure & Mittleman, 2000). Through such sampling, we can capture the natural flow of human behaviour over time and across settings (Myin-Germeys et al., 2009); an important step towards understanding the antecedents and consequences of food intake.

Ideally, EMA studies should collect a maximum of five randomly scheduled assessments in addition to any event-based assessments each day (Burke, Shiffman, et al., 2017). Collecting too few data points reduces the effect size of the study, and issuing too many observations becomes overly burdensome for participants. Burke, Zheng, et al. (2017) ran an EMA study on investigating the triggers of dietary lapses over a 12-month period among individuals who were part of a weight loss program. By piloting and developing an EMA protocol alongside participants, Burke, Zheng, et al. developed supportive infrastructure to promote optimal use and compliance with their study protocol. Some of the infrastructure developments included; the use of participants' own mobile device as the study device so they only had to carry, charge and maintain one phone; an emphasis on training and troubleshooting to ensure participants fully understood the protocol requirements; issuing financial incentives based on monthly compliance; the option to delay or silence random prompts for minimal disruption; and, the use of skip patterns to maximise relevance of assessment questions. By creating flexible and supportive technological infrastructure, participants in Burke, Zheng, et al.'s (2017) study were able to maintain approximately 90%

compliance with the study protocol. This suggests that with the appropriate and flexible infrastructure, long-term use of EMA monitoring is possible.

In summary, EMA is used to report individuals' cognitions and behaviours as they go about their daily lives. There are a variety of assessment schedules which can be applied in EMA studies, each offering its own advantages and disadvantages. The real-world and real-time nature of EMA monitoring makes it a particularly useful technique to assess discretionary food intake. Through the use of EMA, we are able to examine both the intra-individual fluctuations of individuals' eating and cues, as well as the antecedents leading to their food choices (Moskowitz & Young, 2006).

In the EMA studies presented in Chapters 2, 3, 4 and 5 of this thesis, individuals carry a specially-programmed electronic device (HBART; see: https://www.utas.edu.au/health/research/groups/tasmanian-school-of-medicine/clinical/behavioural-and-situational-research-group-bsrg/hbart) to record their eating and drinking for two weeks. Participants included in this thesis engage in event based and randomly-timed assessment monitoring, by using a combination of the two sampling strategies, we are able to compare the presence of cues when an individual is eating compared to when they are not eating (i.e., during random time points throughout the day). Such information is necessary to better understand, and develop targeted interventions aimed to modify individuals' eating patterns.

1.7 Changing eating behaviour

As mentioned in Section 1.4, there are many theories which seek to understand an individual's behaviour. Commonly used Behavioural Change Techniques (BCTs), involve providing information on consequences of ill-health behaviour and goal setting to modify individuals' behaviour. In terms of dieting and weight loss, BCT typically focus on increasing individuals' awareness and importance of their goals (e.g., Aarts, 2007; Dombrowski et al., 2016; Sullivan & Rothman, 2008). The awareness and prioritisation of individuals' goals is believed to motivate individuals towards changing their behaviour (Aarts, 2007; Ajzen, 1991). This thesis will explore how individuals' motivations (i.e., goals and intentions) impact their dietary behaviour; an important step in informing what BCT may be best applied to modify discretionary food intake.

1.7.1 Current treatments for reducing weight and discretionary food intake

Current treatments aimed at reducing individuals' weight and limiting discretionary food intake require individuals to both set goals and monitor their behaviour such as through monitoring their weight, dietary intake and physical activity levels (Collins et al., 2010). Structured commercial weight loss programs have been shown to be more effective for managing individuals in the overweight range than once-off counselling and self-help programs (Heshka et al., 2000). Commercially available weight loss programs offer consumers to participate in internet-based versions of their programs (Neve et al., 2011). Such programs typically encourage individuals to monitor their caloric intake. Additionally, they may offer pre-packaged meals or meal replacements (McEvedy et al., 2017). Some of the largest commercially available weight loss programs include Weight Watchers, Jenny Craig and NutriSystem in the United States (Gudzune et al., 2015).

These weight loss programs are extremely popular. In 2014, Americans spent approximately $2.5 billion on commercial weight loss program (Gudzune et al., 2015). Although the programs can help individuals lose weight in the short-term, the majority of participants do not achieve clinically meaningful weight loss and eventually withdraw from the program (McEvedy et al., 2017; Tsai & Wadden, 2005). Programs which involve calorie counted meal plans are more likely to fail compared to programs which offer pre-packaged meals or meal replacements (McEvedy et al., 2017), suggesting that even when highly motivated to change behaviour, commercial weight loss programs have limited effectiveness in creating long-term behavioural change.

The limited effectiveness of sustained behaviour change may be at least partially due to the design of commercial weight loss programs. Delivering health messages in an online setting means that the programs rely on individuals to log-on and access the health information and maintain their health goals with little assistance. Despite the flexibility that internet-based intervention programs offer, individuals minimally engage with internet-based weight loss resources (Arem & Irwin, 2011). Offering more tailored advice may be a way to promote more substantial weight loss. A review by Webb et al. (2010) found that behaviour change interventions delivered in online settings were enhanced when paired with additional methods of communication (e.g., Short Message Service: SMS, messages). Section 1.7.2 of this thesis outlines how personal technologies can be incorporated in dietary interventions, potentially improving both their accessibility and effectiveness.

Particularly relevant to the context of dietary intake, are external cues such as the availability of food (Cleobury & Tapper, 2014), how one is feeling (O'Connor et al., 2015) and social norms (Vartanian et al., 2017). Incorporating BCT and known determinants of eating may be a way to improve the long-term success of dietary interventions. Examining momentary determinants of eating through the use of real-time monitoring may further our understanding of the cues underlying dietary lapses. This information could be used to create more personalised, evidence-based behaviour change strategies. The use of mobile health (mHealth) may be a way to achieve this.

1.7.2 A move towards developing mHealth apps to change behaviour

Over the past decade, researchers have experimented with the provision of education and advice materials via mobile phone. mHealth solutions were first delivered in the form of text-messages (Whittaker et al., 2016). More recently, researchers have trialled stand-alone behaviour change applications administered via mobile phones (e.g., via "apps" (Zhao et al., 2016). mHealth apps have the potential to improve individuals' health and behavioural outcomes by harvesting and interpreting information about a user's life and using such information to provide personalised intervention content and delivery (Businelle et al., 2016). The provision of content via mobile phones is more than just a "clever use of technology" (Ferguson et al., 2020). Recent technological advances, as well as the near universal availability of handheld devices such as mobile phones, have significantly improved the viability of assessment and intervention strategies utilising such technologies (Kaplan & Stone, 2013).

In traditional therapeutic interventions, therapists attempt to change cognitions within a therapeutic setting, which clients then generalise and apply in relevant situations. Here, individuals are given BCT and strategies in an artificial context removed from the source of the problem (i.e., in the consulting room). Implementing these strategies outside the consulting room can be challenging as individuals are confronted with situational and environmental cues prompting them towards their regular behaviour (VanDeMark, 2007). mHealth interventions, on the other hand, are designed to intervene at the exact moment that dysfunction is triggered. For example, an individual who is dieting may be issued an intervention as their craving and temptation for unhealthy food is escalating. Issuing interventions are likely to be most relevant when they are targeted towards providing solutions for cues triggered in specific contexts.

Issuing health information via the delivery of mHealth apps has been used to target discretionary food intake and overweight/obesity. Examples of mHealth dietary apps include OnTrack (Forman et al., 2018), My Fitness Pal (Laing et al., 2014) and My Diet Coach Pro (Chen et al., 2015). Despite the existence of numerous mHealth apps targeted towards dietary interventions, they are generally not evidence-based and minimally cover energy requirements and nutrition information based on healthy eating guidelines (Chen et al., 2015; Pagoto et al., 2013). Furthermore, they may be improved by identifying a range of triggers relevant to the initiation of unhealthy food intake. Given such gaps in the literature and market exist, further examination into the cues underlying discretionary food intake is essential to best inform mHealth app development.

Although mHealth apps may be particularly useful for individuals who are wanting to monitor their calorie intake (Laing et al., 2014), they generally lack BCT to assist individuals to change. Including BCT into interventions is an essential step in promoting the success of interventions (Webb et al., 2010). Indeed, higher quality apps include more in-built features and more BCT than apps of a low quality (Schoeppe et al., 2017). The most commonly used BCT in mHealth apps revolve around goal setting and feedback (Antezana et al., 2018). Including a variety of BCT is therefore important to inform both treatment content and delivery of mHeath-based interventions.

In summary, including a range of triggers relevant to the initiation of unhealthy food intake and BCT to overcome these triggers is likely to improve the evidence-base and effectiveness of mHealth dietary apps. As EMA methods allow for an examination of the situational and contextual cues guiding eating, EMA studies may be a way forward in identifying potential targets for mHealth dietary interventions. Ultimately, this information can be used to inform a new generation of intervention technologies which can reduce participant burden through passive data collection, while producing highly personalised, contextualised and dynamic tools that learn and interact with the user.

1.8 Current gaps in research

Currently, we do not know enough about how situational and contextual cues may be integrated with individual-level traits and motivations to explain discretionary food intake. Furthermore, as outlined in Section 1.4, the role of motivations and intentions underlying food intake is unknown. Examining the motivational determinants surrounding discretionary food intake will be a key focus of Study 1. Study 2 will explore how TST can be applied to explore the relative impact of motivational and situational influences of eating. Studies 3 and 4 will explore the role of food availability and the neighbourhood food environment in shaping individuals' food intake (each study is explained in greater detail in Section 1.9 below).

1.8.1 Sample characteristics used in previous studies

Previous studies examining eating behaviour have often involved young, undergraduate (generally female) university students (e.g., Herman et al., 2003; McFerran et al., 2010; Thomas et al., 2011; Wahl et al., 2017). Given university students are at a higher risk for weight gain, particularly in their first year of university (de Vos et al., 2015), they may have distinct eating patterns and/or cues shaping their food intake, therefore the determinants underlying their food intake may not be generalisable to a wider population.

Additionally, research examining dieters' behaviour has drawn participants from a demographic consisting mainly of women (e.g., Adriaanse et al., 2009). Typically, these studies have recruited individuals undergoing specific dietary and weight loss interventions (e.g., Avenell et al., 2004; Burke, Zheng, et al., 2017; Forman et al., 2018). Whilst this enables insight into testing the efficacy of the intervention, it does not allow for an understanding of how dieters make their eating decisions on a day-to-day basis, or how situational cues may influence people to not act on their dietary intentions (de Ridder et al., 2017). Therefore, Study 1 in this thesis addresses this gap by examining food intake among individuals who are consciously trying to change their eating behaviour as they go about their daily lives.

Research on social cues influencing eating has mainly been conducted on female participants (e.g., Kaisari & Higgs, 2015; Robinson et al., 2013). Although there is limited research to suggest males are prone to social eating influences in the same way as females (Hermans et al., 2009), sampling males would enable a more comprehensive understanding of the role of social and other external influences to eating more generally. Given the limitations associated with the participant characteristics in previous studies, each of the studies included in this thesis examines the determinants underlying food intake in a community sample of both males and females across a wide age range.

Some research suggests that individuals with overweight and obesity are more responsive to food cues than individuals with lower BMIs (e.g., Ferriday & Brunstrom, 2011; King, 2013; Schüz et al., 2017). Indeed, individuals with overweight/obesity display stronger salivary responses and an increased desire to consume both cued and non-cued foods (Ferriday & Brunstrom, 2011). Heightened reactivity to food cues may predispose individuals towards eating due to hedonic rather than homeostatic hunger, subsequently resulting in excess weight gain (Sobik et al., 2005). However, previous studies generally have not stratified participants based on individuals' BMI— therefore, they were unable to detect differences in the responsivity to food cues based on individuals' current weight. Study 3 specifically recruits individuals with overweight and obesity to examine the influence of stimulus control and the food environment on individuals' food intake. Additionally, Study 4 recruits an even distribution of BMI so that stimulus-control between individuals within the healthy weight range and overweight/obesity can be compared.

1.8.2 Methodological concerns from previous studies examining eating

Much of the previous research on eating has used cross-sectional designs, focusing on between-person differences in food intake (e.g., Davis & Carpenter, 2009; Lucan & Mitra, 2012; Morland et al., 2006). Although such studies can allow for a greater understanding of many individuals' perceptions of their immediate context (for example, the local food environment; Lucan & Mitra, 2012), such designs cannot determine how perceptions of the environment change over time or as individuals move through various environments each day (Chaix et al., 2012). However, food intake is known to substantially change within an individual depending on where they are (Pitt et al., 2017), how they are feeling (Adriaanse, Vinkers, et al., 2011), or the activity they are engaging in (Chapman et al., 2012). Given that food choices change both within and across days, it is important to examine the within-and-between person differences in food choices, and how changes in one's environment may shape their food intake; a key focus of Study 4.

Secondly, as was discussed in Section 1.5.1, previous literature examining the relationship between affect and food intake has traditionally examined eating in laboratory settings (e.g., Bongers et al., 2013; Evers et al., 2013; Oliver et al., 2000). Although laboratory studies can manipulate the environment to examine the causal relationships between variables such as watching an emotionally charged television program and subsequent food intake (e.g., Vartanian et al., 2008), they generally induce only short-term manipulations in affect, which may not translate to changes in food intake after the emotional manipulation has ceased (Evers et al., 2009). As such, research examining the relationship between affect and eating should examine changes in affect as they occur in naturalistic settings. Studies 1, 2 and 3 included in this thesis examine the relationship between affect and eating as individuals go about their daily lives.

Thirdly, research examining the social cues surrounding discretionary food intake has typically attempted to manipulate social norms in the laboratory and see if eating decisions change based on external cues in the environment such as the implied behaviour and presence of others (e.g., Kaisari & Higgs, 2015; Prinsen et al., 2013; Robinson et al., 2013). Although this technique means researchers can explore individuals' reactions to cues surrounding others eating behaviour, it does not explain if individuals prioritise eating the same type, or quantity, of food as presented in the norm conditions. Studies 2 and 3 of this thesis further explore the role of social cues guiding food intake.

An additional concern with laboratory-based studies is that individuals may feel uncomfortable and self-conscious whilst being observed, which may result in them behaving differently to how they would outside the laboratory (Bongers et al., 2013). For example, when Kaisari and Higgs (2015) assessed the influence of dyadic patterns of food intake in the laboratory, they noted that it is possible that laboratory-based eating situations are so unfamiliar that all participants regardless of their familiarity with each other looked to each other to guide appropriate food intake. It is possible that this uncertainly is what influences food choice in laboratory settings, not the influence of peers per se. Given such limitations exist, laboratory studies may lack generalisability to changes in eating occurring in real-world settings. To address these concerns, the studies presented in this thesis explore eating behaviour in naturally occurring settings using EMA methods (see Section 1.6, for an overview of EMA).

In summary, this section has identified current gaps in the literature (see Table 1.2 for a summary of the gaps in the literature and what this thesis examines). This section has outlined issues associated with previous sample characteristics, and how much of the previous research on eating has involved laboratory-based studies, thereby raising concerns regarding the generalisability to real-world environments. The focus on cross-sectional studies has meant that previous research on food intake has examined eating at one point in time, thereby neglecting to account for fluctuations with contextual and individual cues occurring over time and in various settings. Through recruiting community samples, stratifying participants based on their BMI and by using EMA, this thesis seeks to address such gaps in the literature by exploring the individual and contextual determinants of discretionary food intake.

Table 1.2 Summary of gaps in the literature and what this thesis examines

	Focus of previous research	**Gaps/issue**	**What this thesis will examine**
Sample characteristics	• Young, female university students	• Unknown generalisability to others	• Community sample of participants
	• Examine specific dietary interventions	• Influences of daily food choice unknown	• Examine eating as individuals go about their regular lives
	• BMI differences in eating is observed	• Unsure why there are BMI differences in eating	• Stratify sample based on BMI
Methodological limitations	• Cross-sectional designs/examining behaviour at one time point only	• Fluctuation in behaviour/cues unknown	• EMA methods to examine within-person fluctuations in behaviour and cues
	• Laboratory-based manipulations in social cues/environment	• Generalisability to real-world situations is unknown	• EMA methods to examine behaviours in naturally occurring settings

1.9 Objectives of the present thesis

The present thesis aims to investigate the individual and contextual determinants of discretionary food intake. Due to the negative health consequences of overweight and obesity, identifying the determinants of excess energy intake is essential in developing evidence-based interventions to improve population health. Currently, too little is known about the processes shaping discretionary food choice, and research to date has typically focused on examining eating patterns between people or relied on laboratory-based studies on cue reactivity (e.g., Bongers et al., 2013; Evers et al., 2013; Oliver et al., 2000). As such, the present thesis uses EMA to examine the within-person processes driving real-life eating decisions from both a motivational and a momentary perspective. In doing so, this thesis seeks to provide a more comprehensive understanding of the determinants of discretionary food intake than previous research has examined. Such information will inform how to target common eating triggers and promote healthy food choices.

This is a thesis by publication; each Chapter presents a stand-alone study that has already been published. Each study uses EMA methods to explore the determinants of discretionary food intake. This thesis begins by examining how the structure of goals influence the self-regulation of eating (Chapter 2), then applies Temporal Self-regulation Theory to examine snacking from an integrated perspective outlining both the motivational and momentary determinants of snacking (Chapter 3). Study 3 explores the momentary cues guiding snacking such as affect, availability of food, social influence/isolation and the presence and type of food outlets (Chapter 4). Study 4 explores snacking from the influence of the community nutrition environment using Geographical Information Systems data to indicate the availability of food within the local environment (Chapter 5). Together, these studies illustrate the common determinants and consequences of snacking, and how we can best apply interventions to modify discretionary food intake (Chapter 6).

Study 1 (Chapter 2): Inter-goal conflict and facilitation as predictors of adherence to dieting goals: An Ecological Momentary Assessment study

Due to a lack of understanding of how individuals' dieting goals impact upon other idiosyncratic goals they are working towards; Study 1 examines discretionary food intake through a motivational perspective; investigating the role of intention in shaping how individuals prioritise and manage their eating goals. Study 1 involves 94 dieters completing an assessment of their goals using an adapted version of (Little, 1983)'s personal project analysis. Over the first 14 days of a dieting attempt, participants complete an EMA study recording their food intake and daily engagement in their personal goals. The aim of Study 1 is to examine the effect of perceived inter-goal facilitation and conflict on dietary intake.

Study 2 (Chapter 3): Personal and situational predictors of everyday snacking: An application of Temporal Self-Regulation Theory

The relative impact of motivational and situational influences on eating is currently unclear. Study 2 applies Temporal Self-Regulation Theory (TST: Hall & Fong, 2007) to examine both the motivational and momentary factors that shape individuals' eating patterns. Motivational factors towards eating (e.g., past behaviour and self-regulation) are recorded during a baseline study visit, and momentary cues (e.g., individual, situational and environmental factors) are recorded over a two-week EMA monitoring period. Study 2 aims to examine how TST can be applied to understand the determinants of discretionary food choices and provide pathways to interventions that target both motivational and situational factors.

Study 3 (Chapter 4): Situational cues and momentary food environment predict everyday eating behaviour in adults with overweight and obesity

The role of internal (e.g., experiencing negative affect) and external (e.g., seeing others eat and having food available) cues driving eating has previously been explored (e.g., Cruwys et al., 2014; Ferriday & Brunstrom, 2011; Higgs & Thomas, 2016; O'Connor et al., 2015). However, these studies have relied on retrospective assessments, rather than reporting momentary environmental exposures. Additionally, minimal research has examined the cues to eating in a sample of overweight and obese individuals. Individuals with overweight and obesity are more likely to be driven by cues to eat and experience higher food cravings than individuals with lower BMIs (Ouwehand & Papies, 2010; Thomas et al., 2011). Therefore, Study 3 explores the effect of known internal and external cues driving eating in a sample of individuals with overweight and obesity. In this study, fifty-one adults participated in a two-week EMA study, recording their meals and snacks at the time the decision to eat is being made. Study 3 integrates the stimulus control and food environment perspectives and examines the influence of both cues and the momentary food environment on food choice in adults with overweight and obesity.

Study 4 (Chapter 5): Examining the association between food outlets and eating behaviour: A Geographical Information System (GIS) study

Whilst the role of environmental determinants of eating has been examined (e.g., Fuzhong et al., 2009; Thornton & Kavanagh, 2012; Zenk et al., 2009), these studies have typically calculated the presence of food outlets using postcode information. However, individuals are exposed to many different environments as they travel throughout each day, so assessment of the momentary environmental cues may allow for a more comprehensive understanding of the influence of food outlets on eating. Study 4 goes beyond the self-perceptions of environmental cues described in studies 1, 2 and 3, by using objectively collected Global Positioning System (GPS) information to monitor and track the environments individuals move through. Seventy-four participants completed an EMA study where their GPS location was automatically recorded, and participants self-reported information on local food environment and their food intake over a two-week period. The aim of Study 4 is to investigate whether objectively collected location information (through automatic GPS reports) predict snacking beyond subjectively reported environmental cues.

Chapter 2 Inter-goal conflict and facilitation as predictors of adherence to dieting goals: An ecological momentary assessment study[2,3,4,5]

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[2] Extracts of this chapter were presented at an international conference: Elliston, K. G., Schüz, B., & Ferguson, S. G. (2018, August 24). Daily goal conflict and adherence to dieting goals: An ecological momentary assessment study. Paper presented at the European Health Psychology Society conference, Galway, Ireland. (see Appendix 2.1 for Abstract).

[3] This chapter has been published in its current form as: Elliston, K. G., Schüz, B., & Ferguson, S. G. (2019). Inter-goal conflict and facilitation as predictors of adherence to dieting goals: An ecological momentary assessment study. *Psychology & Health*, *35*(6), 1-17. https://doi.org/10.1080/08870446.2019.1684496

[4] The EMA questionnaire used this study is included in Appendix 2.2.

[5] The Baseline questionnaire used this study is included in Appendix 2.3.

The present thesis aims to investigate the individual and contextual determinants of discretionary food intake. This chapter investigates the motivational determinants of eating, represented by the most proximal line surrounding an individual in the socio-ecological model (see Figure 2.1). Specifically, this chapter explores the role of perceived inter-goal conflict and facilitation on individuals dieting behaviour. Through examining how goals influence dieting, we are able to better understand the role of motivations and intentions in discretionary food consumption.

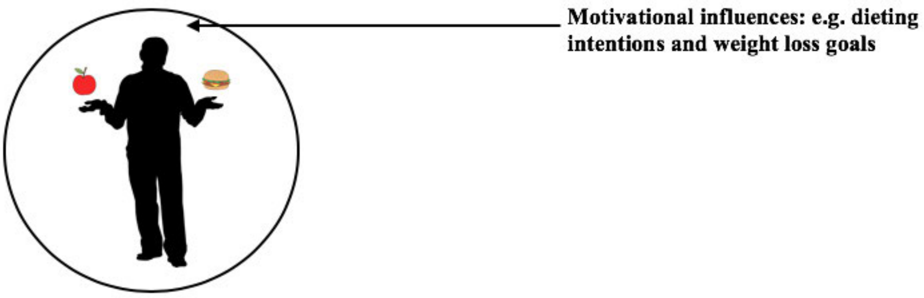

Figure 2.1 Diagram outlining the level of influence for discretionary food intake that will be examined in Chapter 2.

2.1 Abstract

Objectives: To examine dieting goals within a system of individual goals, and the patterns by personally-relevant goals might interfere or facilitate each other.

Design: 94 dieters completed an assessment of goals using Little's personal project analysis. Participants identified 7 goals; one of which was pre-defined as adhering to diet. Over the beginning 14 days of their diet, participants completed an Ecological Momentary Assessment study recording their food intake in real-time. Every evening, participants reported their goal engagement and which goals conflicted or facilitated with each other.

Main outcome measures/results: Over the study duration, 1452 days of food intake and goal conflict/facilitation were recorded. Participants completed an average of 1.54 (*SD*= 0.85) snacks, an average of 0.94 (*SD*= 1.81) goal conflicts, and 4.16 (*SD*= 4.70) goal facilitations per day. Inter-goal conflict was associated with a significant but small improvement on individuals' mood, but was not associated with daily dietary intake or long-term weight-loss. Similarly, inter-goal facilitation was not associated with daily dietary intake or long-term weight-loss. Daily food intake was a significant predictor of long-term weight-loss.

Conclusions: The results of this study suggest the impact of inter-goal conflict and facilitation on dieting is not via overall snack or food consumption.

Key words: dieting; snacking; Ecological Momentary Assessment; goal conflict; goal facilitation

2.2 Introduction

Globally, rates of overweight and obesity are rapidly increasing (Ng et al., 2014); current estimates suggest that over half the adult population is overweight or obese (WHO, 2016). Excess weight places individuals at an increased risk of developing a range of illnesses such as heart disease, diabetes and cancer (AIHW, 2017). Excess weight-gain is largely attributed to an overconsumption of energy and a lack of energy expenditure (Hill & Peters, 1998). Food intake, particularly the consumption of food outside of main meals known as "discretionary foods", is a major contributing factor to excess energy-intake (Hampl et al., 2003). Discretionary foods are generally nutritionally poor, energy-dense and not essential for a healthy diet (Rangan et al., 2009). Despite this, the consumption of discretionary foods is increasing (Zizza et al., 2001). On average, 23-41% of individuals daily energy intake is derived from discretionary foods (ABS, 2015; Rangan et al., 2009; Zizza et al., 2001). Discretionary food intake is often unplanned and is driven by temptations rather than hunger (Cleobury & Tapper, 2014). Due to the health concerns associated with excess energy intake, further investigation into what drives the consumption of discretionary foods is warranted.

Although caloric restriction is a main component of many diets, diets often do not leave individuals with sustained weight-loss over the long term (Mann et al., 2007). In part, this may be the result of difficulties in acting upon multiple goals simultaneously. Dieting is an example of a goal-directed behaviour which is embedded within a system of other goals that individuals are trying to pursue (Kruglanski et al., 2002). Pursuing goals relies on self-control and is therefore dependent on an individual's time, energy and money; the pursuit of one goal will impact the resources available to pursue other personally-relevant goals (Presseau et al., 2010). Goals such as dieting therefore need to be balanced with the demands of numerous competing goals in everyday life (Conner et al., 2016; Riediger & Freund, 2004).

Pursuing a goal can have facilitative or interfering effect on other goals. Sometimes, engaging in a behaviour to achieve one goal increases the motivation and/or performance towards another goal (inter-goal facilitation). This facilitative effect increases the likelihood of successful completion of both goals (Riediger & Freund, 2004); for example, wanting to spend more time outdoors while also having a goal to spend more time exercising. In contrast, pursuing one goal can deplete an individual's resources so they are unable to pursue other goal(s) (inter-goal conflict; Boudreaux & Ozer, 2012). This conflict may be the result of an incompatibility between goals which cannot be performed simultaneously (Riediger & Freund, 2004). For example, wanting to spend more time reading while also having a goal to spend more time exercising. Goal incompatibility results in individuals having to prioritise one goal and dismiss the other(s) (Presseau et al., 2010).

In addition to reduced goal attainment, experiencing goal conflict is associated with impaired psychological well-being (Riediger & Freund, 2004). In a prospective study by (Boudreaux & Ozer, 2012), reporting conflicting goals at baseline was associated with higher levels of negative affect, anxiety, depression and psychosomatic symptoms at 4-6 weeks follow-up. The negative effects from goal conflict may in part be the result of the conflict directing individuals' attention towards the problem, rather than serving as a motivation for addressing the conflict (Riediger & Freund, 2004). Focusing one's attention on the problem exacerbates anxiety towards the improbability of achieving both goals. Overall, individuals who experience high levels of goal conflict are less likely to experience successful goal attainment (Boudreaux & Ozer, 2012).

Previous research has examined the predictive utility of experiencing goal conflict and facilitation on individuals' participation in health and health-risk behaviours such as physical activity (Conner et al., 2016; Presseau et al., 2010; Presseau et al., 2013) and marijuana initiation and use (Simons & Carey, 2003). Dieting involves repeated behaviours within and across days in which goal enactment is particularly burdensome. However, to our knowledge, no study has examined how competing personal goals influence individuals' ability to maintain a diet.

The patterns by which dieting and other goals might interfere or facilitate each other is highly idiosyncratic, so the present study will examine dieting goals within individuals goal systems. The first aim of this study is to examine the effect of perceived inter-goal facilitation and goal conflict on dietary intake. Consistent with literature in the physical activity domain (e.g., Presseau et al., 2013), perceived goal conflict is hypothesised to negatively impact upon goal engagement, and perceived inter-goal facilitation is hypothesised to assist with other personal goals. Consequently, we hypothesise that participants report greater discretionary food intake (as this behaviour is assumed to be incompatible with individual dieting goals) on days when they experience goal conflict(s) compared to days when they did not experience such conflict, and experiencing goal facilitation will lead to better adherence to dieting goals, shown through decreased discretionary food intake.

A second aim of this study is to explore individuals' perceptions of goal conflict through examining the relationship between perceived goal conflict and negative affect. In accordance with Boudreaux and Ozer's (2012) study, goal conflict is expected to result in increased levels of negative affect. Importantly, however, fluctuations in the relationship between perceived inter-goal conflict and negative affect has not yet been examined on a daily level; therefore, this study will explore the association between day-to-day fluctuations in inter-goal conflict and reported levels of daily negative affect. We hypothesise that participants' negative affect will increase as their perceived inter-goal conflict increases.

A third aim of this study is to predict individuals' weight change at 12 weeks after beginning a diet. Specifically, we explore whether self-reported food intake predicts individuals changes in weight over time, and whether the experience of inter-goal conflict/facilitation predicts long-term changes in weight.

2.3 Method

2.3.1 Overview

This study combined a thorough assessment of personal goals through an adapted version of Little's (1983; 2006) Personal Projects Analysis with Ecological Momentary Assessment (EMA: Ferguson & Shiffman, 2011) methods. This allowed us to examine how multiple goal pursuit influenced discretionary food intake and weight among individuals beginning a diet. Over a two-week period, participants used a specially programmed smartphone (HBART: https://www.utas.edu.au/health/research/groups/tasmanian-school-of-medicine/clinical/behavioural-and-situational-research-group-bsrg/hbart) to record their food intake in real time and complete randomly-timed assessments issued throughout each day. Participants location, activity and affect was assessed during both food reports and the randomly-timed assessments. For the duration of the monitoring period, participants also completed daily assessments of their engagement with their personal goals.

2.3.2 Participants

94 dieters were recruited through newspaper advertisements and community weight-loss programs. Eligibility criteria included being ≥18 years old, beginning a diet within one week of beginning participation in this study and having no history or diagnosis of an eating disorder. Upon completion of the study, participants received an AUD$50 shopping voucher as reimbursement for their time. Ethics approval was

obtained from the Tasmanian Social Science Human Research Ethics Committee (reference number: H0016081).

The majority of participants were female (84.04%; *n* = 79) with an average age of 37.78 years (*SD*= 17.10). The majority (68.08%; *n* = 64) were Caucasian/European, with the remaining participants predominantly being of Asian descent (25.53%; *n* = 24). Approximately a third (39.36%; *n* = 37) of the participants had graduated from university, and a further 26.59% (*n* = 25) had completed some university. Approximately three-quarters (73.40%; *n* = 69) participants were dieting to lose weight, 8.60% (*n* = 8) were dieting to maintain weight and 17.20% (*n* = 16) for other reasons such as for general health benefits, or lowering cholesterol.

2.3.3 Procedure

Participants completed three study visits over two weeks of monitoring their food and drink intake and engagement in their personal goals. During the first study visit, participants provided written informed consent, their height and weight was measured by study staff to calculate Body Mass Index (BMI) [(kg/[height(m)^2], and participants completed a baseline survey of their eating habits and participants relationship with food using the Yale Food Addiction Scale (Gearhardt et al., 2009) and the Power of Food Scale (Cappelleri et al., 2009). During this visit participants also completed a qualitative assessment of their personal goals using the framework of Little's (1983) Personal Project Analysis. Consistent with Presseau et al.'s (2013) study, participants were asked to create a list of goals they were actively engaging in that best characterise their everyday life. In the current study, in order to reduce participant burden, participants were only required to list six personal goals. In addition, a seventh "adhering to diet" goal was included in all participant goal lists. Participants rated the importance of each of their goals, and how they generally impact upon one another.

Following the development of personal goal lists, participants engaged in two weeks of EMA monitoring, where they recorded their food and drink intake in real-time using an electronic diary. During each food report, participants specified whether their food intake was a main meal or a snack. In order to reduce participant burden, a random subsample (60%) of the food reports were followed by a set of questions asking about participants current state (mood, hunger and craving level) as well as contextual and situational details surrounding the food intake (location, activity they were engaging with, and who was around). In addition to self-initiated reporting of every food intake over the monitoring period, participants were issued a similar set of questions asking about contextual and situational details on average 4-5 times each day (randomly-timed assessments). At the end of each day (between 7pm and midnight), participants completed a global assessment of their mood, craving, exercise, instances where they restrained themselves from eating and reported daily food intake. During the end of day report, participants engaged in an episode reconstruction where they were shown their personal goal listings and reported which of their goals they had engaged in throughout the day, and which goals conflicted and/or facilitated with one another (see assessment of goal engagement below). Participants could continue reporting food intake and responding to randomly-timed assessments until they completed a self-initiated report stating they were going to bed (available from 8pm).

During the second study visit, participants data was uploaded, and the study staff provided EMA retraining as necessary. After 14 days of recording food and drink intake and engagement in personal goals, participants returned for their final study visit, where they self-reported their weight and were weighed by study staff (the two measurements of weight were highly correlated: $r = 0.997$, $p < .001$). During this visit, a final upload of participants data was completed, EMA devices were returned, and participants received an AUD$50 shopping voucher for their time. 10 weeks after the EMA monitoring period was complete (three months after participants began a diet), participants were re-contacted via phone to report if they were continuing their diet and update the researchers of their current weight.

2.3.4 Measurement Instruments

Following previous EMA studies (e.g., Schüz, Schüz, et al., 2015), *food intake* was assessed in both real-time reports and during an end-of-day summary report. For the duration of the two-week monitoring period, participants self-reported by tapping a button on the smartphone each time they ate or drank (real-time reports). Participants categorised their food intake as either a snack or a main meal. Assessing food intake in this way has been shown to correspond with previous research on daily food consumption (Elliston et al., 2017). In addition, food intake was assessed at the end of each day, where participants were asked "how many meals consumed today" and "how many snacks consumed today?" In order to account for missed food reports, the report with the highest number of recorded food intakes (either the real-time or end-of-day report) was used for the analysis. The analyses looked at food intake in terms of both the number of snacks consumed each day and a tally of total daily food intake.

Goal conflict/facilitation was measured during participants end-of-day reports. Assessments of goal conflict/facilitation were based on Little's (1983) Personal Project Analysis framework, following similar questions asked in Presseau et al. (2013). Unlike previous studies, perceived goal conflict/facilitation was assessed on a daily basis. Participants were asked to reflect upon their day in three-hour windows (6-9am, 9am-12, 12-3pm, 3-6pm) and select which of their seven goals they engaged in during each time period (responses ranged from 0= did not engage in any of their goals in this time period, to 7= engaged in all goals during this time period). Next, participants were asked to select which (if any) of the goals they engaged with conflicted during each time frame (responses were categorised as either 1= goal conflict present, to 0= absence of goal conflict). This process was repeated to assess perceived experiences of inter-goal facilitation throughout each day. A tally of daily goal conflict and facilitation was used in the analysis to compare dietary intake across days with varying levels of goal conflict and facilitation.

Negative affect was assessed during the randomly-timed assessments. For the purposes of this study, we focused on negative affect as negative affect rather than positive affect has been shown to increase food intake among individuals restraining their eating (e.g. Evers et al., 2018; Macht, 2008). During the randomly-timed assessments, participants were asked to indicate their overall feeling from 1 (very good) to 5 (very bad). Higher scores indicate higher levels of negative affect. Affect scores reported in the randomly-timed assessments were averaged to provide an indication of participants daily level of negative affect.

Weight-change was measured by comparing participants' weight at baseline with their weight at the 10-week follow-up period. Individual weight change was calculated in terms of percentage of weight-loss. In accordance with the NHMRC (2012) guidelines, weight-loss was deemed successful if the individual had lost 5% of their recorded baseline weight. For study aim three (predicting weight-loss at 3-month follow-up), only those participants who reported dieting with the aim to lose weight were included in the analyses.

2.3.5 Analytical Procedure

The data in this study involved repeated daily assessments (of inter-goal facilitation/conflict, and negative affect) and observations (of snacking and overall food intake (total of meals and snacks)) for each individual. The data was hierarchically organised such that daily measurements of dietary intake, negative affect and inter-goal conflict/facilitation (Level 1) were nested within individuals (Level 2). Therefore, hierarchical linear models were used to examine the variability both within participants

(Level 1) and between participants (Level 2). Analyses for study aims 1 and 2 were run in R using either the glmer function (study aim one), or the lmer function from the lme4 package (study aim two; Bates et al., 2015). Analyses for study aim 3 were run in MPlus using maximum likelihood estimation with robust standard errors (MLR). For each study objective, a series of models were fitted whereby each predictor was added to the model and a likelihood ratio test— using the anova function— was used to determine whether the predictors added to each model significantly improved model fit. Predictors which did not significantly add to the model were dropped.

To address our first objective; examining the effect of perceived inter-goal conflict and facilitation on dietary intake, occurrences of goal conflict within each three-hour window was dichotomised as either occurring (1= presence of inter-goal conflict) or not occurring (0= absence of inter-goal conflict). Instances of reported goal conflict were then summarised to provide an indication of the number of daily conflicts experienced per person (possible range: 0-28, reported range: 0-12 inter-goal conflicts). This assessment was repeated for the experience of inter-goal facilitations (participants reported experiencing a range between 0-28 instances of goal facilitation per day). Conflict experience was participant mean-centred to indicate days on which participants experienced more or less conflicts than their personal average.

To address our second objective; to explore participants' perceptions of goal conflict, we examined the relationship between inter-goal conflict(s) and daily level of negative affect. Consistent with the analysis for study aim one, we dichotomised the presence of inter-goal conflict within each three-hour time frame (1= goal conflict present, 0= absence of goal conflict). Then we summarised occurrences of inter-goal conflicts across each day and calculated deviation scores of goal conflict to predict participants daily level of negative affect.

In order to address the third aim— whether self-reported food intake relates to weight change over time— the number of snacks, and the combination of meals and snacks were summed up per person/day. For those participants who were dieting with the aim of losing weight, we calculated the change in body weight as percent of baseline weight lost. Daily snack intake (within-participants) was then used to predict percentage weight change (between participants) at the 10-week follow-up call. This process was repeated for overall food intake predicting weight-change at the follow-up call. To examine whether self-reported goal conflict/facilitation related to weight change over time, the number of daily goal conflicts and inter-goal facilitations were summarised per person/day and used to predict percentage weight change at the 10-week follow-up call.

2.4 Results

In total, 98 participants enrolled in the study and were given EMA devices. Four participants withdrew before completing one day of EMA monitoring, leaving a final sample of 94 participants (see Figure 2.2). In total 1,452 days of food intake and goal conflict/facilitation were recorded: M= 15.59 (SD= 1.57) monitoring days/person. Participants' compliance with the randomly-timed assessments was good (M= 77.96%, SD= 17.84). Consistent with previous studies (e.g. Schüz, Schüz, et al., 2015), days where compliance with the randomly-timed assessments was below 50% were excluded from analysis (total 230 days; 15.84% of total days).

Participants completed 4,231 food reports; 1,592 were snacks, averaging 1.54 (SD= 0.85) snacks per participant per day. Overall inter-goal conflict occurred on 21.76% of monitoring days; M= 0.94 (SD=1.81) goal conflicts per person/day. However, 15.96% (n= 15) participants did not report any days of goal conflict over the monitoring period. Overall, inter-goal facilitations occurred on 48.72% of monitoring days; M= 4.16 (SD= 4.70) goal facilitations per person/day. A minority of participants

(7.45%, *n*= 7) did not report experiencing any days of inter-goal facilitation over the two-week monitoring period.

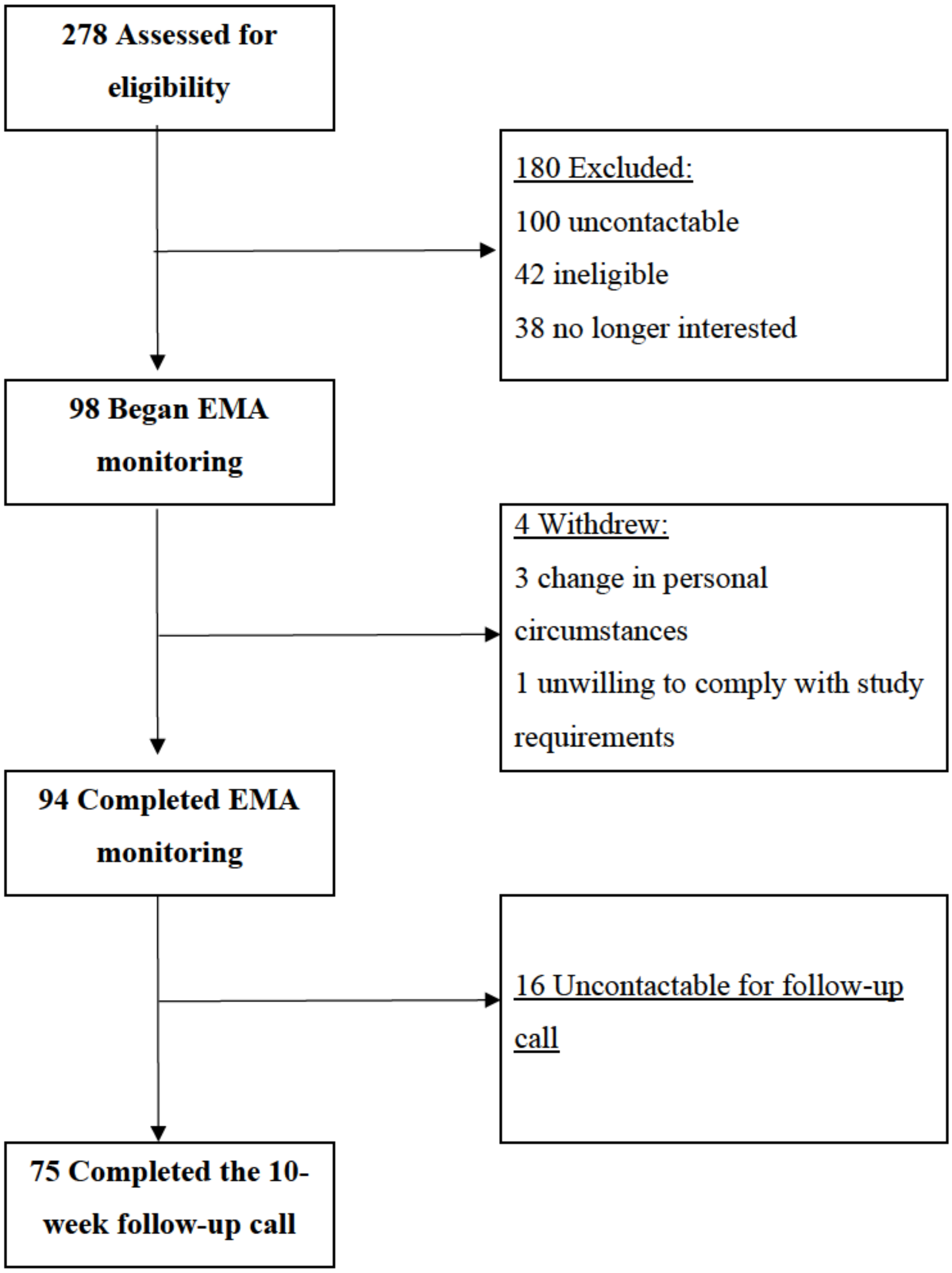

Figure 2.2 Participant flow diagram

2.4.1 The effect of inter-goal conflict and facilitation on daily dietary intake

A random intercept, fixed effects model showed that experiencing a higher number of goal conflicts per day did not predict daily snack intake (see Table 2.1, model 1). Adding a random slope of conflict deviation did not improve model fit, neither did adding in day in study. Similarly, the number of daily goal conflicts was not a significant predictor of overall food intake.

When looking specifically at the adhering to diet goal, conflict between any personal goal and the dieting goal did not predict daily snack intake (see Table 2.1, model 2). Similarly, the number of daily goal conflicts with the adhering to diet goal did not predict overall food intake.

Similarly, experiencing a higher number of inter-goal facilitations per day did not predict daily snack or overall daily food intake (see Table 2.2, model 1). Adding a random slope of facilitation deviation did not improve model fit, neither did adding in day in study. Experiencing inter-goal facilitation specifically with the adhering to diet goal also did not predict snack or overall food intake (see Table 2.2, model 2). Adding a random slope of facilitation deviation did not improve model fit, neither did adding in day in study.

Table 2.1 Results from aim one: examining the role of inter-goal conflict and daily dietary intake

Dietary intake measure		Model 1[a]	Model 2[b]
Daily snack intake	Fixed effects (level 1)		
	Intercept snack total	0.29(0.06)***	0.29(0.06)***
	Goal conflict	0.02(0.02)	0.00(0.05)
	Random effects (level 2)		
	s^2 Intercept subject	0.29(0.54)	0.29(0.54)
Daily food intake	Fixed effects (level 1)		
	Intercept food total	1.37(0.03)***	1.37(0.03)***
	Goal conflict	0.01(0.01)	-0.00(0.03)
	Random effects (level 2)		
	s^2 Intercept subject (*SD*)	0.05(0.23)	0.05(0.23)

Note. Entries are reported as *B*(*SE*), where *B*= coefficient estimate, *SE*= standard error, **p*<.05, ***p*<.01, ****p*<.001

[a] denotes models where instances of inter-goal conflict were summarised and deviations scores were entered in the model

[b] denotes models where goal conflict represents the occurrences of conflicts specifically with the dieting goal (summarised together and deviation scores were entered into the model)

Table 2.2 Results from aim one: Examining the role of inter-goal facilitation on daily dietary intake

Dietary intake measure		Model 1[a]	Model 2[b]
Daily snack intake	Fixed effects (level 1)		
	Intercept snack total	0.29(0.06)***	0.29(0.06)***
	Goal facilitation	-0.00(0.01)	-0.04(0.03)
	Random effects (level 2)		
	s^2 Intercept subject	0.29(0.54)	0.29(0.54)
Daily food intake	Fixed effects (level 1)		
	Intercept food total	1.37(0.03)***	1.37(0.03)***
	Goal facilitation	0.00(0.00)	-0.00(0.02)
	Random effects (level 2)		
	s^2 Intercept subject (*SD*)	0.05(0.23)	0.05(0.23)

Note. Entries are reported as *B*(*SE*), where *B*= coefficient estimate, *SE*= standard error, *p<.05, **p<.01, ***p<.001

[a] denotes models where instances of inter-goal facilitation were summarised and deviation scores were entered into the model

[b] denotes models where goal facilitation represents the occurrences of facilitations specifically with the dieting goal (summarised together and deviation scores were entered into the model)

2.4.2 Perceptions of inter-goal conflict

Perceived inter-goal conflict was associated with a small, but significant decrease in negative affect (see Table 2.3). We started with a random intercept, fixed effects linear model which included goal conflict predicting level of negative affect and found that adding in day in study as a predictor improved model fit (Δ-2 log likelihood= -798.64, df= 5, p <.001). The results suggest that negative affect increases by day in the study and decreases slightly when participants experience inter-goal conflict.

Table 2.3 Results from aim two: exploring perceptions of inter-goal conflict through participants experience of negative affect

	Coefficient Estimate (*Standard Error*)
Fixed effects (level 1)	
Intercept negative affect	2.29(0.06)***
Goal conflict	-0.03(0.01)***
Day in study	0.01(0.00)***
Random effects (level 2)	
Intercept subject (*SD*)	0.26(0.51)
Residual ($\sigma^2_{\mu 0}$, *SD*)	0.23(0.48)

Note. Model calculated based on instances where inter-goal conflict were summarised and deviation scores were entered into the model.

*p<.05, **p<.01, ***p<.001.

2.4.3 Weight change over the first 12 weeks of dieting

The majority (69.15%, *n*= 65) of the sample had an initial Body Mass Index (BMI) placing them in the overweight/obese range; mean BMI measured at baseline was 29.49 (*SD*= 7.35). The majority of participants (58.51%, *n*= 55) reported they were continuing with their diet during the 10-week follow-up call. During this time, participants reported a weight change between -36.7kg and +4.1kg (mean weight-loss was 3.09% of baseline body weight, *SD*= 4.78%). In total, 18 participants lost more than 5% of their initial body weight over the first three months of their diet and were deemed successful in their weight-loss attempt. Participants' baseline weight (*M*= 86.14, *SD*= 23.52) was significantly higher than their weight recorded during the 10-week follow-up period (*M*= 83.56kg, *SD*= 20.42): $t\ (676) = 13.60$, $p < .001$.

A mixed effects linear model showed there was a positive relationship between the number of daily snacks consumed during the two-week monitoring period and changes in weight during follow-up (see Table 2.4, model 1). Participants who consumed fewer daily snacks reported greater weight loss at the 10-week follow-up. A similar effect was found for self-reported daily food intake; less daily food intake was associated with more weight-loss (Table 2.4 model 2).

When looking at the experience of inter-goal conflict and facilitation over the monitoring period, reported goal conflict was not associated with changes in weight-status at follow-up (Table 2.5, model 1), neither was reported goal facilitation (Table 2.5, model 2).

Table 2.4 Results from aim three: predicting weight-loss at three months post dieting from daily snack and daily overall food intake

	Model 1[a]	Model 2[b]
Fixed effects (level 1)		
Daily dietary intake on day	-0.09(0.05)	-0.08(0.06)
Residual	0.99(0.01)***	0.99(0.01)***
Random effects (level 2)		
Intercept weight change	-1.49(0.21)***	-2.48(0.42)***
Weight change on dietary intake	0.43(0.09)***	0.48(0.12)***
σ^2 Weight change	0.81(0.08)***	0.77(0.12)***

Note. Entries are reported as *B*(*SE*), where *B*= coefficient estimate, *SE*= standard error, *p<.05, **p<.01, ***p<.001

[a] daily snack intake was entered into the model

[b] daily overall food was entered into the model

Table 2.5 Results from aim three: predicting weight-loss at three months post dieting from experiences of daily goal conflict and facilitation during the monitoring period

	Model 1[a]	Model 2[b]
Fixed effects (level 1)		
Experience of goals on day	-0.05(0.06)	-0.06(0.06)
Residual	1.00(0.01)***	1.00(0.01)
Random effects (level 2)		
Intercept weight change	-0.69(0.16)***	-0.36(0.31)
Weight change on goal experience	0.04(0.10)	-0.29(0.27)
σ^2 Weight change	0.99(0.01)***	0.92(0.16)***

Note. Entries are reported as *B*(*SE*), where *B*= coefficient estimate, *SE*= standard error, **p*<.05, ***p*<.01, ****p*<.001

[a] instances of reported daily goal conflict were entered into the model

[b] instances of reported daily goal facilitation were entered into the model

2.5 Discussion

The present study examined how personal goals influence individual's ability to maintain a diet and explored discretionary food intake and goal conflict/facilitation on weight-loss among individuals beginning a diet. The results suggest that neither perceived inter-goal conflict nor facilitation affect individuals' discretionary food intake. The results also demonstrated experiencing inter-goal conflict is associated with a small decrease in negative affect. Together these results suggest that inter-goal conflict/facilitation may not be relevant in the context of dieting. In terms of weight-loss, the results showed decreases in discretionary and overall daily food intake predicted the percentage of weight change during the follow-up call. However, there was no significant effect of goal conflict/facilitation on long-term weight-loss. Nevertheless, the difference between baseline and follow-up weight was significant, suggesting that participants reached their goals (to some degree), but their weight-loss goals may have been reached via other means than inter-goal facilitation.

Neither inter-goal conflict nor inter-goal facilitation were significant predictors of discretionary food intake or overall daily food intake. This suggests that the experience of goal conflict itself is not enough to impact upon dieting behaviour among those who are focused on changing their eating patterns. Indeed, experiencing goal conflict has been found to not impact engagement in other health related behaviours such as physical activity (Conner et al., 2016; Presseau et al., 2010). Individuals may self-regulate the perceived conflict in such a way that minimises the impact of the conflict on achieving other personally-relevant goals (Presseau et al., 2010). Although the current study did not measure self-regulation, a similar self-regulation technique may have been employed by individuals to minimise the impact of goal conflicts. Participants in our study must have engaged in some form of self-regulation to lose weight, but the resulting behavioural change was less affected by goal conflict than theorised, and in fact, less than what participants thought; participants reported conflict between dieting and their other goals, but the conflict seemingly had no influence on their day-to-day dietary intake.

In contrast to our second hypothesis, experiencing inter-goal conflict was associated with decreased levels of negative affect. It is possible that our measure of goal conflict did not adequately capture conflicting goals that were stress-inducing. Riediger and Freund (2004) found global evaluations of inter-goal interference to be associated with lower psychological wellbeing. However, their measures of both psychological wellbeing and inter-goal conflict were more generalised to longer-term effects than our measures of daily negative affect and daily inter-goal conflict. Participants in our study may have reported experiencing goal conflicts when in fact, the conflicts were only minor inconveniences that had no real impact upon their day. Alternatively, the impact of goal conflict on psychological functioning may be additive; changes in affect may occur after a long period of being exposed to numerous and severe inter-goal conflicts. Further investigation into participants perceptions and experiences of goal conflict is therefore warranted.

Daily food intake was a significant predictor of participants weight-loss over the first three months of their dieting attempt, which suggests reducing food intake was one way participants were changing their energy balance. However, given that neither the experience of inter-goal conflict nor inter-goal facilitation was associated with weight-change, it is possible that experiencing inter-goal conflict has other effects on food intake. For example, participants may have changed the quality of foods they were eating. Individuals may eat more unhealthy snacks after experiencing goal conflict(s) and stress, and may eat healthier foods when experiencing facilitation with dieting goals. Indeed, a study by Zellner et al. (2006) found that the quality of foods individuals consume when stressed shift to more high caloric, high fat snacks compared to what they would normally consume. Therefore, future studies should explore the changes in food type during a self-guided dieting attempt and whether goal conflict/facilitation is associated with changes in the quality–rather than the overall number– of foods consumed.

Whilst our study examined tallies of goal conflict and facilitation across the day, it is also possible to assess goal conflict/facilitation in terms of the amount of time spent engaging in various activities. Indeed, Presseau et al. (2013) examined inter-goal conflict and facilitation through calculating the time participants spent pursuing goals perceived to conflict/facilitate with physical activity. However, given physical activity guidelines outline exercise goals in terms of duration, and insufficient time is commonly regarded as a barrier to exercise, using time-based assessments of physical activity and goal conflict/facilitation is appropriate. Dietary intake on the other hand, may be less susceptible to time-based conflicts, therefore summarising instances of goal conflict seems more relevant. Nevertheless, as we divided the day into a series of three-hour time frames, it is possible that instances of inter-goal conflict or facilitation could have occurred outside of our sampling window.

Alternatively, goal conflict/facilitation may be able to be measured through examination of approach and avoidance systems. Approach behaviours are those which seek rewarding stimuli and avoidance behaviours aim to avoid punishing or threatening stimuli (Corr, 2013). In the context of dieting, an approach behaviour may be viewed as seeking more healthy food options. On the other hand, avoidance may be demonstrated through avoiding unhealthy foods. Failure to engage in approach and/or avoidance behaviours may imply an underlying presence of inter-goal conflict. Approach and avoidance goal distinctions may moderate the effects of goal facilitation/conflict on health behaviour. Future studies should further explore the different ways to operationalise goal conflict and facilitation and whether approach and avoidance systems moderate engagement in health behaviour goals.

2.5.1 Strengths, limitations and future research

This study has several strengths; to our knowledge, this study was the first in the eating literature to qualitatively assess individuals' goals and evaluate how their goals impact upon their day-to-day life. Through feeding back individuals' idiosyncratic goals at the end of each day, we were able to assess how engagement with personal goals changes both within and across days, and how personal goals go through periods of conflicting and facilitating one another. This provides a greater understanding of how individuals manage and prioritise their goals to engage in health-related behaviours.

The use of repeated daily assessments of perceived goal conflict and facilitation and dietary intake allowed us to examine changes in dietary intake across situations for each individual. Examination of within-person changes in dietary intake is necessary to understand the triggers and lapses of individuals dieting goals (Carels et al., 2001). Repeated assessments of dietary intake through EMA, allows for the estimation of risk of antecedents to occurrences of overeating/dietary lapses (Burke, Shiffman, et al., 2017). This information could be used to inform personalised dietary advice and/or interventions to help individuals eat healthier and lose weight.

Participants in this study were given the opportunity to report any food intake that was not recorded during the day in the end-of-day summary report. Assessments of daily dietary intake was then summarised using a combination of the real-time and end-of-day summaries. Through assessing food intake in this way, we were able to collect as accurate representation of participants daily food consumption as possible.

Despite these strengths, there are some methodological limitations to this study. Firstly, we looked at overall snack intake, instead of specifically examining changes in the quality of the food participants consumed. It is possible that the type of foods participants consumed may have changed (Zellner et al., 2006), which may not have been reflected in the summaries of dietary intake. Nevertheless, our summary of discretionary food intake and overall food intake (discretionary food intake and main meal consumption) is in line with previous literature (e.g. Richard et al., 2017) and provides an indication of self-reported dietary intake, allowing us to examine how it changed over time. Additionally, it is possible that some diets encourage more frequent, but smaller portions of food intake, which in turn is not reflected in the way we assessed adherence to dieting goals. However, given the results showed daily snack intake predicts long-term weight-loss, assessing food intake through the number of snacks consumed each day seems an appropriate way to evaluate the relationship between dieting goals and weight loss.

The number of daily food intakes did not correspond to how inter-goal conflict and facilitation were assessed in relation to the 'adhering to diet' goal. It may have been better to correspond the dieting goal with an avoidance goal specifically related to food intake, for example, a goal of 'not snacking'. However, we did not collect information on the specific goals underlying participants' diets, therefore we were unable to do this. Future studies should explore whether the non-significant findings relating to goal conflict and daily dietary intake were a correspondence issue and whether specific avoidance goals should be considered instead.

It is possible that participants did not accurately report their food intake, which may explain why food intake was not associated with long-term weight-loss. However, previous studies have found daily snack consumption to be in line with our findings (e.g. Piernas & Popkin, 2010; Richard et al., 2017). Furthermore, because EMA studies are designed to get individuals to complete reports in real-time, there are less prone to memory biases that complicate results in traditional pen-and-paper diaries (Berkman et al., 2014). Reporting events in real-time is less confronting than having to recall all events and provide a summary at the end of each day. Previous research (e.g. Berkman et al., 2014; Liao et al., 2018) suggests that individuals with higher BMIs may find reporting their food intake- particularly energy-dense foods- to be more aversive than their lower BMI counterparts. The use of EMA may overcome some of these issues.

Asking participants to monitor their eating behaviour may have further created an intervention effect where the dieting goal was temporarily prioritised over other idiosyncratic goals. In this sense, the ‘adhering to diet’ goal may have overridden pre-existing inter-goal conflicts and facilitations. However, unlike intervention studies, participants electronic devices did not display a tally of their food consumed over the day, so the effect of monitoring food intake is expected to be minimal. Indeed, previous EMA studies with similar monitoring requirements have found that asking participants to complete reports throughout the day has minimal effect on their perceptions and behaviours (e.g., Stone et al., 2003). For example, asking chronic pain patients to record their pain throughout the day did not alter their perceptions of pain (Stone et al., 2003). This was the case even when the frequency of monitoring was increased (and therefore more attention was given to pain experiences). Similarly, in our study it is not expected that asking dieters to report their food intake would significantly alter the priority of their dieting goals, however future studies should explore this further.

Despite having a relatively large sample size, participants reported at least one inter-goal conflict on less than one quarter of the monitoring days. On days where inter-goal conflict(s) was reported, the number of goal conflicts per person was quite low. Furthermore, some of the sample did not report any goal conflict over the monitoring period. A combination of the low percentage of days with goal conflict and the low number of goal conflicts occurring per day, may have resulted in an underestimation of the effect of goal conflict on snack intake. It is possible that there was an insufficient spread of reported goal conflicts, which may have masked the effect of conflict on food intake. A similar pattern occurred for inter-goal facilitation; goal facilitation occurred on less than half the days in the monitoring period. Future studies should qualitatively explore how participants perceive goal conflict/facilitation, which may help to explain why conflict/facilitation was only reported on a small proportion of the monitoring days. Future research may also wish to examine the impact of goal conflict/facilitation closer to the moment in which it is occurring so that we can develop a better understanding of how idiosyncratic goals influence momentary behavioural engagement.

In this study, we did not account for how participants ranked the importance of each of their goals. Previous research has found goals which are perceived to be of a high priority, predict intentions and engagement in health behaviours (e.g., Conner et al., 2016). However, as the current study targeted recruitment towards individuals who were actively trying to change their eating patterns, it was expected that the ‘adhering to diet’ goal would be among participants most highly rated personal goals. If this was indeed the case, it is possible that the experience of inter-goal conflict and/or facilitation were insufficient to override this priority goal and alter participants mood and behaviour. Obtaining a qualitative assessment of inter-goal conflict and facilitation would help to explain how participants navigated complications associated with their goal hierarchies.

Finally, collapsing affect scores from over the day into a daily average may limit the generalisability of our findings relating to negative affect. Affect may fluctuate significantly within the course of a day (Haedt-Matt & Keel, 2011), and this fluctuation may be what drives changes in behaviours such as eating (Goldschmidt, Crosby, et al., 2014). Events (perhaps even goal conflicts) driving negative affect may result in an immediate behavioural change that is not seen when affect is averaged over a day. For example, spikes in negative affect have been associated with binge eating among adults with obesity (Berg et al., 2015). If a spike in negative affect occurs only once during the day, the number of discretionary foods eaten over the day may remain unchanged; masking the relationship between negative affect and discretionary food intake. A more thorough examination of fluctuations in negative affect and discretionary food intake is therefore needed.

2.6 Conclusion

Examining the day-to-day changes in goal conflict/facilitation is an important step in understanding how individuals prioritise and manage their goals. This study found inter-goal conflict has a significant but small impact upon individuals' mood, but this does not result in a change in the overall daily dietary intake. Similarly, inter-goal facilitation was not associated with individuals' daily dietary intake. Daily food intake and discretionary food consumption was not a significant predictor of long-term weight-loss. The results of this study suggest the impact of inter-goal conflict and facilitation on individuals beginning a diet is not via overall snack or food consumption.

Chapter 3 Personal and situational predictors of everyday snacking: An application of Temporal Self-Regulation Theory[6]

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As stated previously, the present thesis aims to investigate individual and contextual determinants of discretionary food intake. The previous chapter examined the eating patterns and dieting goals of individuals at the beginning of a dieting attempt; thereby exploring the role of motivational determinants on eating. Results from Study 1 suggest that motivational determinants, such as dieting goals and intentions, may not be that important in guiding real-time eating decisions.

This chapter (Study 2), further examines the motivational determinants of food intake, in conjunction with some momentary-level factors which may prompt discretionary food consumption (see Figure 3.1). Here, the interplay of individual (i.e., motivational determinants, such as behavioural intentions, behaviour pre-potency and self-regulatory capacity) and contextual cues (i.e., momentary factors such as seeing others eat, experiencing negative affect and having food available) are explored through applying Temporal Self-Regulation Theory (TST: Hall & Fong, 2007) to eating.

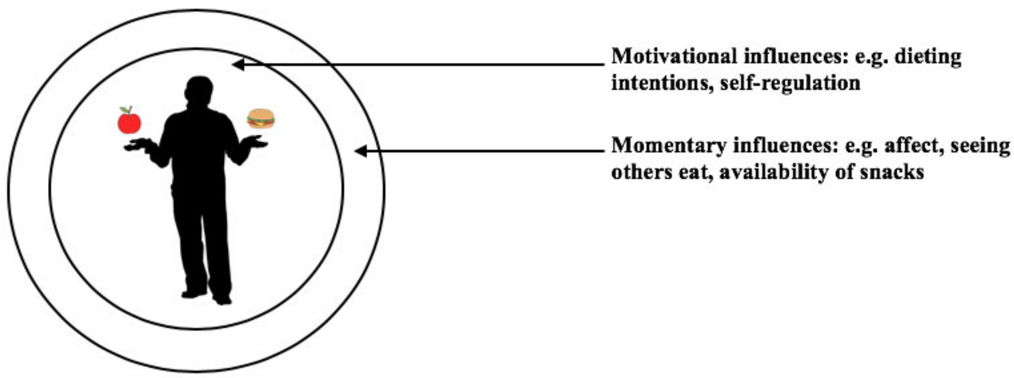

Figure 3.1 Diagram outlining the motivational and momentary influences of discretionary food consumption that are examined in Chapter 3.

3.1 Abstract

Objectives: This study aims at testing predictions derived from Temporal Self-Regulation Theory (TST) in relation to discretionary food choices (snacks). TST combines a motivational sphere of influence (cognitions and temporal valuations resulting in intentions) with a momentary sphere (encompassing social and physical environmental cues). This dual approach differs from current health behaviour theories, but can potentially improve our understanding of the interplay of personal and environmental factors in health behaviour self-regulation.

Design: A mixed event-based and time-based (Ecological Momentary Assessment) study in 61 adults aged between 18 and 64, with a BMI range between 18.34 and 39.78 (M= 25.66, SD= 4.82) over two weeks.

Methods: Participants recorded their food and drink intake for two weeks in real-time using electronic diaries. Participants also responded to non-consumption assessments at random intervals throughout each day. Momentary cues (individual, situational and environmental factors) were assessed both during food logs and non-consumption assessments. Motivational factors, past behaviour and trait self-regulation were assessed during baseline.

Results: Multilevel logistic regression analyses showed that across all snack types, environmental cues and negative affect were associated with an increased likelihood of snacking. Perceiving a cost of healthy eating to occur before eating was associated with an increased likelihood of snacking, whereas intentions and self-regulation were not.

Conclusions: Discretionary food intake is largely guided by momentary cues, and motivational-level factors, such as intention and self-regulation, are less important in the initiation of discretionary food intake.

Key words: Snacking; Ecological Momentary Assessment; Temporal Self-Regulation Theory; Cued eating; Food choices

3.2 Introduction

Excess weight places individuals at an increased risk to develop a range of diseases and negative health outcomes (WHO, 2016). Global rates of overweight and obesity have increased dramatically over the past 30 years (Finucane et al., 2011; Ng et al., 2014), which makes understanding the modifiable risk factors behind obesity a crucial endeavour. Put simply, obesity results from prolonged periods of energy imbalance between energy intake and energy expenditure (Hill & Peters, 1998).

One of the key behavioural determinants of this energy imbalance is food intake, in particular the intake of discretionary foods (Hampl et al., 2003). Discretionary foods are foods which are consumed outside of the main meal times of breakfast, lunch and dinner (Ovaskainen et al., 2006) and typically include energy-dense, nutritionally-poor food items such as biscuits, confectionary, pastries and alcohol (Rangan et al., 2009). In Australia— where the current study was conducted— it has been estimated that the proportion of the daily energy intake derived from discretionary foods is approximately 30-41% depending on age (ABS, 2015; Rangan et al., 2009). What makes the intake of discretionary foods particularly challenging to understand is the fact that they are generally consumed in an unstructured way, such as in-between main meals or sometimes in place of meals (Ovaskainen et al., 2006).

3.2.1 Theoretical approaches to explain snacking behaviour

In order to explore modifiable determinants of discretionary food intake (hereafter referred to as “snacking”), theoretical frameworks are needed that consider the specific nature of snacking behaviour: its discretionary nature and the momentary influences that prompt individuals to snack. However, snacking is also a behaviour that is regulated by individuals’ motivations and goals (Stroebe, Mensink, et al., 2008). Current social-cognitive models of health behaviour acknowledge the role of expectancy*values approaches and intentions in determining behaviours (see Stroebe, Papies, et al., 2008 for an overview of eating theories). However, social cognitive theories neglect the temporal valuations of behavioural outcomes, and, more importantly, remain silent as to the determinants of behaviour such as snacking in a given situation (Hall & Fong, 2007). Cue-reactivity theories on the other hand consider food intake the result of environmental and contextual influences. Factors such as the sight or smell of foods (Coelho et al., 2009; Jansen, 1998) social modelling (Cruwys et al., 2014), and internal cues such as negative affect (Conner et al., 1999) can all serve as cues to eating. However, these approaches rarely specify the influence of conscious, deliberate decisions. This suggests that more integrated theoretical approaches that take into account both deliberate and momentary influences on health behaviour might be useful to explore snacking.

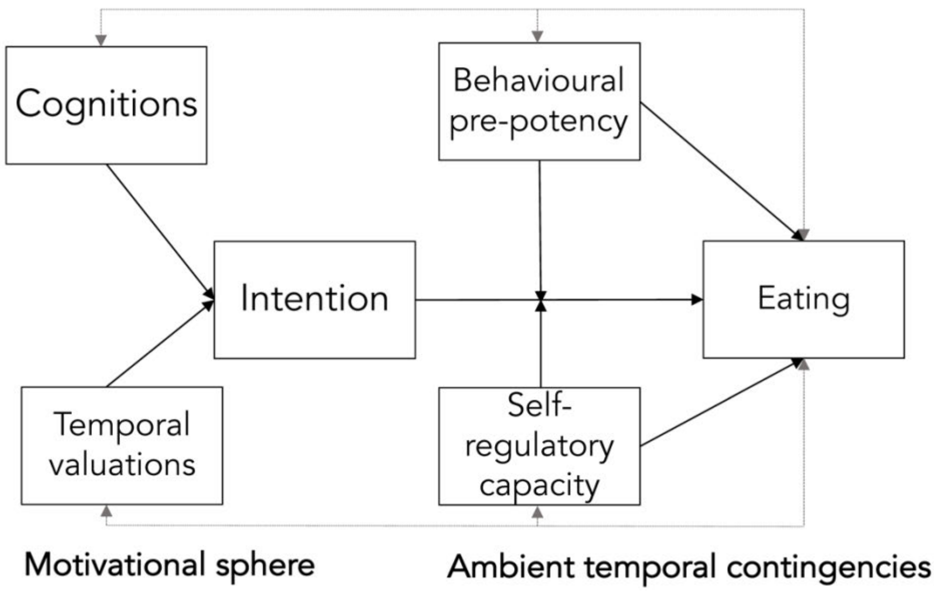

Figure 3.2 Conceptual diagram of TST adapted from (Hall & Fong, 2007).

3.2.2 Temporal self-regulation theory and snacking

One such theory that takes into account both distal, temporally antecedent and motivational influences on behaviour as well as momentary, temporally close and ambient influences is Temporal Self-Regulation Theory (TST: Hall & Fong, 2007; Figure 3.2). TST assumes two broad ‘spheres’ of influence on self-regulated behaviour such as snacking– a motivational and a momentary sphere.

The *motivational sphere* describes conscious deliberations whether or not to engage in a behaviour; this includes in particular temporal valuations about the time points when positive or negative consequences of the behaviour can be expected. These temporal valuations inform intention to perform or refrain from behaviour (Hall & Fong, 2007). Individuals who are motivated by long-term positive behavioural contingencies of healthy nutrition are more likely to engage in health-protective behaviours (i.e., refrain from unhealthy snacking), whereas those who focus on seeking short-term gratification tend to be more impulsive and engage in health-risk behaviours (and are therefore more likely to consume discretionary foods; Hall & Fong, 2007). This sphere of influence is similar to that of other social-cognitive theories (Garcia & Mann, 2003) in that it results in a deliberate decision to engage in behaviour, intention.

While the motivational sphere factors influence overall behaviour, TST also operationalises a sphere of momentary influence or ‘ambient temporal contingencies’. These include situational and environmental cues that trigger behaviours as well as individual-level variables that determine how people behave in a given situation (‘behavioural pre-potency’ describing momentary influences as well as the influence of past behaviour and habit, and ‘self-regulatory capacity’; Hall & Fong, 2007). This sphere is especially relevant to understanding snacking, as snacking is often unplanned and is guided by momentary cues (Grenard et al., 2013) rather than deliberate decisions (Cleobury & Tapper, 2014). Previous research on snacking suggests that these influences include cues such as seeing others eat, the experience of negative affect, proximity to food outlets, and having snacks available. Observing others eat might prompt a social modelling effect (Cruwys et al., 2014; McFerran et al., 2010; Prinsen et al., 2013). Negative affect influences an individual's motivation to eat (Hepworth et al., 2010), often resulting in the increased consumption of energy-dense snacks (Oliver et al., 2000). Being in close proximity to food outlets and having food available serve as facilitators for snacking. The omnipresence of food in the environment provides individuals with frequent opportunities to snack (Hill & Peters, 1998). Furthermore, the types of food stores in the environment are differentially associated with residents' weight status. Previous studies have found a positive relationship between fast-food outlet density and increases in the rates of residents with overweight and obesity (e.g., Fuzhong et al., 2008; Kestens et al., 2012), and recent research has indicated that the presence of food outlets influences momentary food choices (Elliston et al., 2016).

In addition to situational cues, behaviour in the moment is also assumed to be affected by more time-invariant influences: 'Self-regulatory capacity' involves an individual's ability to direct attention away from undesired tendencies towards goal-driven behaviour (Baumeister et al., 1994). Individuals with higher levels of self-regulation find it is easier to withstand cues and refrain from unplanned snacking (Stok et al., 2015). 'Behavioural pre-potency' consists of a combination of varying situation-specific influences and a more stable component that describes how likely someone is to engage in a given behaviour based on their past engagement with that behaviour (Hall & Fong, 2007). When a behaviour is frequently performed within a specific context, the execution of the behaviour becomes automated, requiring less conscious and intentional effort to be initiated (i.e., it becomes a habit; Aarts & Dijksterhuis, 2000). Together, these time-varying and more stable components form an integrative theoretical framework that combines a motivated and ambient sphere of influences on behaviour, which is likely to encompass relevant determinants of snacking behaviour.

3.2.3 Aims of the present study

The present study aims to examine how TST can be applied to understand the determinants of discretionary food choices and provide pathways to interventions that target both motivational and situational factors. While it has been shown that TST can predict healthy lifestyles in general (e.g., Booker & Mullan, 2013), and eating as well as snacking (Collins & Mullan, 2011; Evans et al., 2017), these previous studies on TST relied on longitudinal designs that did not allow a temporal resolution fine enough to test TST predictions for the momentary influence sphere. This is important, as TST implies a multilevel structure of health behaviour, in which behaviour in a given situation (level-1) is predicted both by environmental and momentary factors on this level as well as person-level (level-2) variables, in particular the temporal contingencies of costs and benefits of health behaviour, intention, behavioural pre-potency and self-regulatory capacity.

In this study, we therefore aim to combine both baseline and real-time monitoring using Ecological Momentary Assessment (EMA) methods to examine the effects of TST-based determinants of snacking behaviour. The baseline component of the study will provide an assessment of stable individual characteristics (behavioural pre-potency, self-regulatory capacity) and predictors of motivation, whereas the momentary assessments will examine momentary and situational factors (i.e., seeing others eat, experiencing negative affect, being in close proximity to food outlets, and having snacks available). In particular, we expect that real-time snacking behaviour can be predicted by both individual characteristics, intention, as well as momentary influences.

3.3 Method

3.3.1 Overview

This study used EMA (Ferguson & Shiffman, 2011) methods to test predictions based on TST. Participants used a mobile phone running study-specific software to log every time they consumed food or drink and to respond to randomly timed non-consumption assessments over a two-week monitoring period. Individual, situational and environmental cues were assessed both during food logs and during randomly-timed non-consumption assessments.

3.3.2 Participants

Individuals from the general population were recruited through social media (Frandsen et al., 2014; Frandsen et al., 2016) and flyer advertisements. Eligibility criteria included being between the ages of 18 and 65, have a BMI in the normal- to obese range (18 kg/m^2 - 40 kg/m^2), not be currently dieting, and no history or current diagnosis of an eating disorder. Upon completion of the study, participants received AUD$50 shopping voucher as compensation for their time and efforts. Ethical approval was obtained from the Tasmanian Social Science Human Research Ethics Committee (reference number H0014439).

The final sample comprised of sixty-one adults. The sample size was based on cluster number and cluster size recommendations for estimating robust standard errors for regression weights and variances in a simulation study (Maas & Hox, 2005). The majority of participants were female (42, 68.9%) and had an average BMI of 24.97 (*SD*= 4.07). The majority of participants were Caucasian/ European (59, 97%), with an average age of 32.33 years (*SD*= 12.90); all lived in urban areas (ABS, 2011). Approximately half (30, 49.18%) of the participants had graduated from university, and a further (20) 32.78% had completed some university.

3.3.3 Procedure

This study followed a mixed event-based and time-based design, the procedure was adapted from previous studies (e.g., Schüz, Bower, et al., 2015; Schüz, Schüz, et al., 2015). Briefly, participants completed three study visits and two weeks of real-time real-world monitoring. The first visit was for participants to sign an informed consent form, complete a baseline questionnaire assessing sociodemographic information and general eating patterns, and receive training on how to use the EMA device. After 2-3 days of EMA monitoring (see below), participants returned to the laboratory for their EMA data to be uploaded, their compliance checked and rectify any issues they were experiencing. On completion of the 14-day monitoring period, participants returned for a final study visit during which they returned their EMA device and received a reimbursement.

During the field monitoring, participants were required to log— by tapping a button on the study device— every time they ate or drank. In order to reduce participant burden, only a random subsample (60%) of these logged events were then selected for assessment (Schüz et al., 2014). When a food event was logged, participants were asked to classify the event as either a main meal or a snack.

In addition to self-reporting food and drink consumption, participants were prompted on average 4-5 times a day at for non-consumption assessments. These non-consumption assessments (random prompts) were programmed to not appear 15 minutes after a food or drink log. During the evening, a final report was issued where participants set an alarm for the study to begin recording the next day. The completion of this report meant that no further assessments were issued until the next morning.

3.3.4 Measurement instruments

Temporal contingency was assessed during the baseline questionnaire following the measurement outlined in (Hall & Fong, 2007). Participants were asked to imagine themselves in a situation where they are about to have a meal or a snack and they choose a low-calorie food option over a high-calorie one. They were then asked to think about when the costs and benefits of making this healthy food choice would occur. Responses ranged from 1= ‘when I am thinking about whether or not to make a healthy food choice’, to 9= ‘after making healthy food choices regularly for several decades’. Participant responses were grouped according to perceived costs (overall *M*= 3.28, *SD*= 1.80) and benefits (overall *M*= 5.28, *SD*= 1.85). Costs and benefits were then broken down as occurring either before or during eating, with the perceived costs and benefits occurring after eating forming the reference category for the analysis. Higher scores in the temporal contingency measure indicate more distal effects, whereas lower scores indicate more immediate effects. Overall, costs were perceived to occur sooner than benefits of healthy eating.

Intention to make healthy food choices was assessed during the baseline questionnaire where participants were given a statement ‘I intend to make more healthy food choices’, measured on a five-point Likert scale (1= strongly disagree, 5= strongly agree). Overall, the mean level of intention to make healthy food choices was 4.03 (*SD*= 0.75).

Consistent with previous studies (e.g., Booker & Mullan, 2013; Hall & Fong, 2007) *behavioural pre-potency* was assessed by examining the frequency of past behaviour. At baseline, participants were asked ‘on how many days during the last week have you eaten at least five portions (servings) of fruit and vegetables?’ (possible scores ranged from 0 to 7, with higher scores indicating greater consistency in past healthy eating behaviour). Overall, the mean for behavioural pre-potency was 5.20 (*SD*= 2.10).

Self-regulation was measured in the baseline questionnaire using the 13-item brief self-control measure (Tangney et al., 2004). A mean score for each participant was calculated and used in the analysis as an indication of self-regulation. The overall mean level of self-regulation was 3.12 (*SD*= 0.66).

Snacking behaviour was assessed using during the event-based assessments in EMA, i.e., participants reported every time they had food. Participants self-classified their food as being either a snack or a main meal. Snack types were assessed based on the Dietary Targets Monitor (Lean et al., 2003). Snacks were classified into high-and low-energy based on the food group as an indication of their energy and saturated fat content (Schüz, Schüz, et al., 2015). High-energy snacks included foods such as sweets, chocolates, ice cream, cakes/ scones/ pastries, biscuits, starchy foods, fish, chips, meat products, poultry cheese, crisps and savoury snacks. Low-energy snacks included foods such as fruit and vegetables.

Situational cues were assessed during both the time-based (random prompts) and event-based (food reports) assessments in EMA. This means that an identical set of cues was assessed during both types of reports, allowing subsequent comparisons between these two types of reports. Participants were asked whether they could see others in the environment eat (coded as 1= yes, 0= no), whether snacks were available (1= yes, 0= no) and were they within a 5-minute walk to franchised or other fast-food (coded as 1= yes, 0= no), or shops (supermarket or hypermarket, smaller food shop, convenience store, specialty food shop, chemist or bargain shop (1= yes, 0= no); see Elliston et al., 2016 for a more detailed description of this measure). To determine the cues associated with increased snacking, the presence/absence of each cue during snacking was compared to those present during non-consumption assessments. Previous research (e.g., Hepworth et al., 2010; Schüz, Bower, et al., 2015) has shown negative affect serves as a cue to eating, and has seen negative affect included in TST assessments (Booker & Mullan, 2013). Hence, the current study assessed the experience of negative affect instead of positive affect. Negative affect was assessed with 6 items scored on a 0-100 scale based on the circumplex model of affect (Russell, 1980). To identify meaningful changes in negative affect, scores were then divided by 10 to reflect a 10-point change in negative affect.

3.3.5 Analytical Procedure

Our objective was to examine the utility of TST in predicting snacking behaviour in real-time. Therefore, for each assessment (snack log and non-consumption assessment), the odds of a report being a snack or non-consumption assessment was predicted from motivational and momentary covariates (Elliston et al., 2016; Schüz, Bower, et al., 2015). To account for the hierarchical nature of the data with measurement occasions (level-1 units) nested within participants (level-2 units), a multilevel logistic regression analysis with random intercepts was used for this analysis. All predictors were entered into the model simultaneously. MPlus was used for the analysis of results, using maximum likelihood estimation with robust standard errors (MLR).

In these analyses, the odds of snacking at any measurement point were predicted from momentary and situational factors (ambient temporal contingencies; presence or absence of environmental cues: level-1 variables) and person-level factors (i.e., perceived cost and benefit of healthy eating, individuals' intention to eat healthier, behaviour pre-potency and level of self-regulation: level-2 variables). Level-1 predictors were centred around the person mean, and level-2 variables were centred around the group mean (Enders & Tofighi, 2007) to allow the interpretation of level-1 effects as within-person effects and level-2 effects as between-person effects. Costs and benefits were dummy coded as before and during eating (1) vs. after eating (0).

3.4 Results

Overall, there were 4,879 observations from 776 monitoring days available for analysis (*M*= 14.87 days per participant, *SD*= 2.10 days). Participants completed 2,761 food reports, of which 1,634 (59.18%) were main meals and were excluded from further analysis. A total of 1,127 snacks were reported, averaging 1.51 (*SD*= 1.09) per participant per day; with an average of 0.86 (SD= 0.75) high-energy snacks and 0.65 (*SD*= 0.48) low-energy snacks per day. Consistent with previous studies (e.g., Schüz, Bower, et al., 2015), days where random prompt compliance was below 50%, were excluded from analysis (total 130 days; 14.35% of days monitored). After removing days with poor compliance, participants completed 2,058 (86.69%) non-consumption assessments (*M*= 2.75 per day).

3.4.1 Predicting Overall Snacking

The multilevel logistic regression analyses suggest that the odds of snacking overall compared to random prompts are significantly increased in the presence of momentary cues (seeing others eat, negative affect and snack availability predicted individuals overall snack intake) on level-1. Proximity to fast food outlets and shops were not significant predictors. In terms of person-level (level-2) variables, only temporal contingency significantly predicted the intercepts of snacking: Those who perceived the cost of healthy eating to occur *before* the eating event were more likely to consume snacks (see Figure 3.3c). Intention to eat healthier, individuals' past eating behaviour (behavioural pre-potency), and self-regulation were not significant predictors for overall snack intake (Table 3.1).

3.4.2 High-energy snacks

In terms of momentary cues, the odds of high-energy snacks were higher in the presence of seeing others in the environment eat and with higher levels of negative affect. There was no association between high-energy snack consumption and proximity to food outlets, whether that be proximity to fast food outlets or shops (see Table 3.2).

Similar to overall snacks, an individual's intention and behavioural pre-potency were not significant predictors of high-energy snacking. Self-regulatory capacity however significantly predicted the intercepts of snacking: those with lower-levels of self-regulation had higher intercepts of high-energy snacks than those with higher levels of self-regulation, which indicates a higher overall likelihood of snacking (see Figure 3.3d). In terms of temporal contingency, perceiving costs of healthy eating to occur *before* eating significantly predicted high-energy snack intake (Figure 3.3a), perceiving costs of healthy eating to occur during eating did not have an effect on the likelihood of an individual consuming a high-energy snack, nor did perceiving benefits of healthy eating.

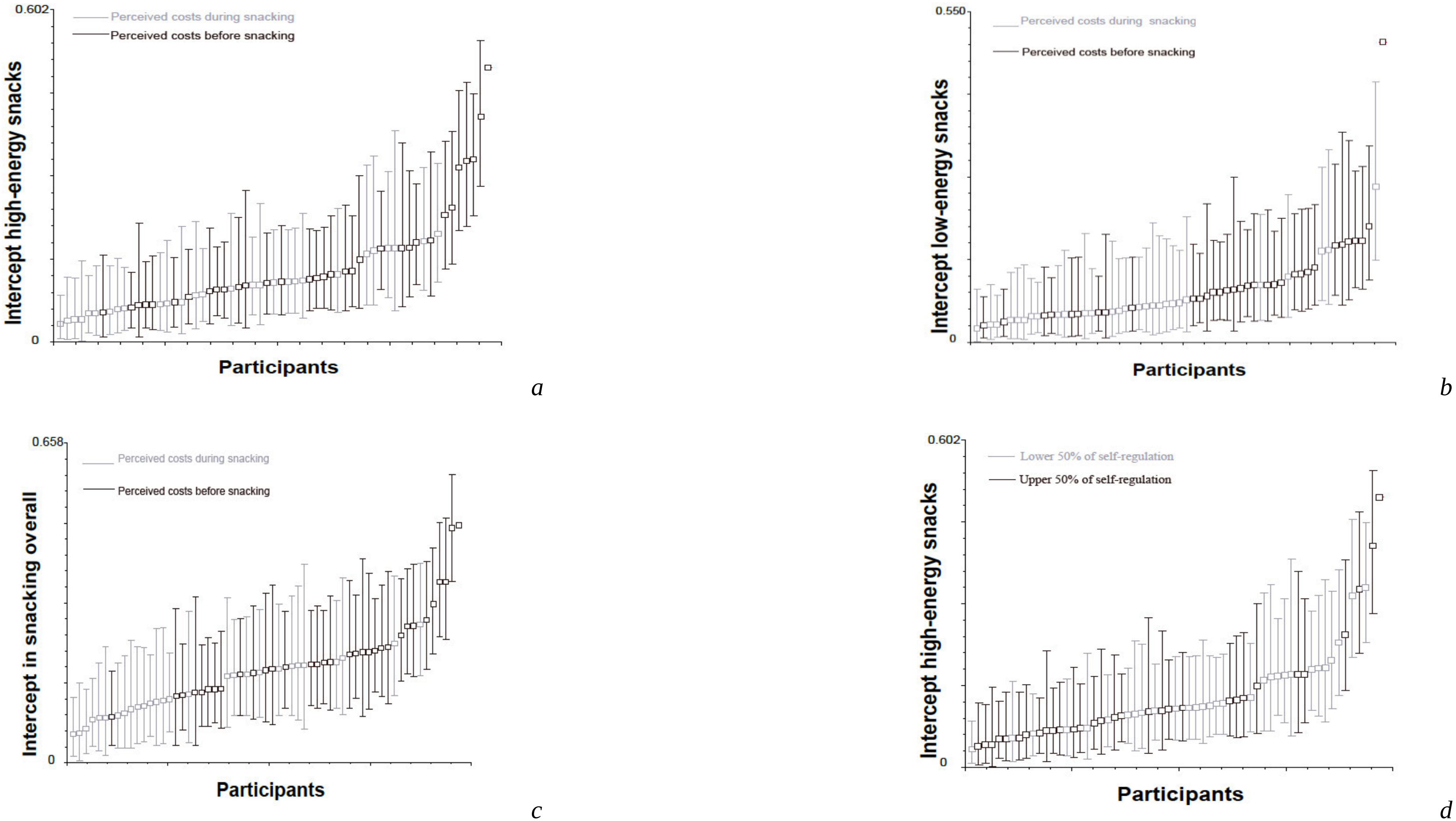

Figure 3.3 Participants ordered by the intercept (95% CI) of logistic regression predicting different types of snacks versus random prompts.

Shading indicates temporal contingencies (costs, panels a, b, c) and self-regulation (panel d).

Table 3.1 Summary of random effects multinomial logistic regression analysis: parameter estimates, standard errors and odds ratios of each covariate cueing overall snack intake.

	Parameter estimate (*SE*)	Odds ratio (95% CI)
Level-1 variables		
Others Eating	1.08 (0.12)***	2.94 (2.30, 3.71)
Negative affect	0.16 (0.04)***	1.17 (1.09, 1.27)
Proximity to fast-food outlets	-0.09 (0.14)	0.92 (0.70, 1.20)
Proximity to shops	-0.04 (0.12)	0.96 (0.77, 1.21)
Snack availability	1.21 (0.18)***	3.39 (2.37, 4.84)
Day in study	-0.04 (0.01)***	0.96 (0.94, 0.99)
Intercept	-2.51	
Level-2 variables		
Cost before eating	0.57 (0.19)**	1.77 (1.23, 2.56)
Cost during eating	0.09 (0.23)	1.10 (0.69, 1.74)
Benefit before eating	0.04 (0.23)	1.04 (0.66, 1.62)
Benefit during eating	0.26 (0.29)	1.30 (0.74, 2.29)
Intention	-0.04 (0.12)	0.96 (0.75, 1.22)
Behavioural pre-potency	-0.02 (0.05)	0.98 (0.89, 1.07)
Self-regulation	-0.31 (0.16)	0.73 (0.53, 1.01)

Note. $^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

Parameter estimates on level-2 variables are interactions with the intercept

Table 3.2 Summary of random effects multinomial logistic regression analysis: parameter estimates, standard errors and odds ratios of each covariate cueing high-energy snack intake.

	Parameter estimate (SE)	Odds ratio (95% CI)
Level-1 variables		
Others Eating	1.38 (0.16)***	3.97 (2.91, 5.42)
Negative affect	0.19 (0.05)***	1.21 (1.10, 1.33)
Proximity to fast-food outlets	-0.05 (0.16)	0.95 (0.69, 1.31)
Proximity to shops	0.03 (0.14)	1.03 (0.78, 1.36)
Snack availability	1.59 (0.24)***	4.92 (3.07, 7.89)
Day in study	-0.02 (0.01)	0.97 (0.95, 1.00)
Intercept	-3.52	
Level-2 variables		
Cost before eating	0.52 (0.21)**	1.68 (1.12, 2.52)
Cost during eating	0.02 (0.25)	1.02 (0.62, 1.68)
Benefit before eating	-0.43 (0.35)	0.65 (0.33, 1.29)
Benefit during eating	0.18 (0.37)	1.20 (0.59, 2.46)
Intention	-0.03 (0.15)	0.97 (0.72, 1.30)
Behavioural pre-potency	-0.06 (0.06)	0.94 (0.84, 1.05)
Self-regulation	-0.59 (0.20)**	0.55 (0.37, 0.82)

Note. **p* < .05, ***p* < .01, ****p* < .001

Parameter estimates on level-2 variables are interactions with the intercept

3.4.3 Low-energy snacks

The momentary cues that predicted low-energy snack intake were limited to only seeing others eating in the environment, and having snacks available. Negative affect and food outlet proximity were not associated with an increased likelihood of low-energy snacking (see Table 3.3). In terms of temporal valuations, perceiving a lower cost of healthy eating to occur before snacking significantly predicted low-energy snack intake (Figure 3.3b). Intention to eat healthier, behavioural pre-potency, and self-regulation were not significant predictors for low-energy snack intake (see Table 3.3).

Table 3.3 Summary of random effects multinomial logistic regression analysis: parameter estimates, standard errors and odds ratios of each covariate cueing low-energy snack intake.

	Parameter estimate (SE)	Odds ratio (95% CI)
Level-1 variables		
Others Eating	0.44 (0.19)*	1.55 (1.07, 2.26)
Negative affect	0.14 (0.08)	1.15 (0.98, 1.35)
Proximity to fast-food outlets	-0.12 (0.27)	0.89 (0.52, 1.52)
Proximity to shops	-0.20 (0.23)	0.82 (0.52, 1.27)
Snack availability	1.03 (0.30)***	2.78 (1.55, 5.06)
Day in study	-0.04 (0.02)*	0.96 (0.93, 0.98)
Intercept	-3.40	
Level-2 variables		
Cost before eating	0.50 (0.25)*	1.65 (1.00, 2.72)
Cost during eating	0.17 (0.42)	1.85 (0.52, 2.71)
Benefit before eating	0.57 (0.29)*	1.76 (1.00, 3.12)
Benefit during eating	0.39 (0.31)	1.48 (0.81, 2.71)
Intention	0.10 (0.16)	1.10 (0.80, 1.51)
Behavioural pre-potency	0.04 (0.07)	1.04 (0.91, 1.19)
Self-regulation	0.13 (0.20)	1.14 (0.77, 1.69)

Note. *p < .05, **p < .01, ***p < .001

Parameter estimates on level-2 variables are interactions with the intercept

3.5 Discussion

The aims of the current study were to examine the antecedent and momentary determinants of discretionary food choices (snacking), a main contributor to energy imbalance and obesity, by applying Temporal Self-Regulation Theory (TST: Hall & Fong, 2007). Using multilevel modelling, we found that momentary cues to snacking were important determinants of snacking, and that the person-level motivational predictors of behaviour intention, behavioural pre-potency and self-regulatory capacity appeared to be somewhat less important than the momentary environment. The study was the first to examine TST using the implied multilevel structure with both person- and occasion-level predictors for health behaviour using EMA.

3.5.1 Momentary environment of snacking

When looking at the effects of the momentary environment on snacking, the results of this study broadly replicate those of earlier research. In particular, seeing others in the environment eat was associated with an increase in the likelihood of snacking. This pattern has been reported in previous studies (Elliston et al., 2016; Schüz, Bower, et al., 2015; Schüz, Schüz, et al., 2015). The underlying pathways for these social effects could be due to social modelling (Cruwys et al., 2014).

Consistent with previous research (e.g., Groesz et al., 2012; O'Connor et al., 2008; Schüz, Bower, et al., 2015), negative affect was associated with an increased likelihood of snacking for both high-energy and overall snack intake. Negative affect might lead to self-control failures (Baumeister, 2002), making it more likely that individuals will be unable to resist food temptations. Stress in particular often creates a strong desire to eat (Groesz et al., 2012), and consuming high-energy foods reduces perceived stress (Sominsky & Spencer, 2014). Equipping individuals with stress-management strategies may reduce the effects of negative affect on discretionary food intake.

Contrary to previous studies (e.g., Elliston et al., 2016; Fuzhong et al., 2008; Kestens et al., 2012), the present study did not find proximity to food outlets to predict snacking. While this study used an identical protocol to Elliston et al.'s (2016), this previous study included only individuals with overweight and obesity in their sample, whereas the present study did not restrict participants BMI range. It is therefore possible that the non-significant relationship between snacking and food outlets was due to the BMI sample; BMI may moderate the relationship between momentary cues and snacking.

Having snacks available and easily accessible was associated with an increased likelihood of snacking. Exposure to food cues increases individuals' motivation to eat and subsequently the likelihood of their eating (Ferriday & Brunstrom, 2011; Sobik et al., 2005). Reducing the availability of snacks from specific environments, such as in the home or office, is likely to weaken the temptation to snack, thereby assisting individuals to maintain a healthy diet (Greenwald, 2006).

The results suggest that overall and low-energy snacking decreased the longer participants were in the study. This could mean that high-energy snacks were more salient (Spence et al., 2016) and are therefore remembered more easily and reported more frequently than low-energy snacks. Question-behaviour effects whereby repeatedly assessing behaviour could lead to changes in behaviours (Wilding et al., 2016) are less likely, as these would suggest uniform change in behaviour over time. Future studies may wish to examine this further, and investigate any changes in high vs. low-energy snack consumption over time.

3.5.2 Motivational sphere predictors of snacking

Aside from perceiving a cost of healthy eating to occur before eating, temporal contingency evaluations were generally not predictive of snacking. Engaging in immediate benefits behaviours, such as snacking, is easier than engaging in behaviours with only distal benefits, such as healthy eating (Hall & Fong, 2007). Therefore, any perception of having a cost associated with healthy eating is likely to result in snacking. Additionally, momentary cues such as the attractiveness of foods prime hedonic eating goals (Papies, 2012), thereby increasing the temptation to engage in snacking.

Intention to eat healthier was not associated with the odds of a measurement occasion being a snack report or a random prompt, regardless of snack type. While this seems to contradict previous studies on the role of intentions for eating behaviour and snacking in particular (e.g., Allan et al., 2010; Onwezen et al., 2016), it is important to note that this result pertains to predicting snacking at any given moment rather than the prediction of an accumulated pattern of snacking behaviour, such as in previous longitudinal research that predicted summative accounts of snacking. However, it seems to suggest that momentary eating behaviour might be less controlled by deliberation than indeed by momentary cues to eat. This might be due to self-regulatory challenges occurring in the momentary environment (Baumeister, 2002) where momentary cues to snack could have posed too overwhelming challenges to the self-regulation of goal-directed behaviour. At the same time, many of the cues might have been included in habit-like cognitive structures triggering behaviour (snacking) in the presence of these cues (Verhoeven et al., 2012).

Past behaviour as one indicator of behavioural pre-potency did not predict the odds of snacking in any model. While this finding might seem to contradict the role of past behaviour and habit as a direct influence on momentary behaviour, we rather think that the limitations of our assessment of pre-potency precluded from detecting an effect. Theoretically, behavioural pre-potency indicates a habit-like predisposition of a person to act in a specific way in a given situation. Previous research (e.g., Booker & Mullan, 2013) has assessed this via an indicator of past behaviour, which has informed the present study. However, this assessment does not indicate habit strength, which could be conceptualised as a moderator of the relationship between cues and behaviour. In fact, recent research by Evans et al. (2017) shows an indicator of habit strength to be associated with the intake of unhealthy snacks. Future research should thus consider examining behavioural pre-potency via the assumed moderating role of habit strength on the association between situational cues and behaviour.

Finally, lower levels of self-regulation were associated with higher intercepts of high-energy snacking. This is consistent with previous research which demonstrates that higher levels of self-control are associated with health protective behaviours, and lower levels are associated with ill-health behaviours (Hagger et al., 2009; Keller et al., 2016; Tangney et al., 2004). Higher levels of trait self-regulation might have enabled individuals to prioritise intentions or health goals over impulses in situations requiring resisting external cues. Of note, similar to recent research by Evans et al. (2017), we used a trait measure of self-regulation (Tangney et al., 2004), which differs from previous operationalisations of self-regulatory capacity as executive control (Booker & Mullan, 2013; Hall & Fong, 2015). This selection was guided by considerations that self-reports of self-control factors seem to be better able to measure the behavioural processes implied in successful self-control (Allom et al., 2016) and, for the purpose of this study, provided a better fit to theoretical assumptions. Self-regulation however, can fluctuate over time according to present situational factors (Hofmann et al., 2012) and thus has potentially time-varying influences on health behaviour. The present study only assessed baseline levels of self-regulation, precluding from analysing fluctuations over time. Future research might consider operationalising and examining variations in self-regulation as an influence factor in the momentary sphere.

3.5.3 Limitations

There are some methodological limitations to the current study. Firstly, the study was correlational. Although this study highlights the cues associated with snacking, we cannot determine if these cues caused individuals to snack; there may have been other factors causing individuals to snack that were not examined. Furthermore, due to its repeated measures design, the study has more power to detect effects of situational predictors on level-1 (within-participants), than to detect effects of the motivational predictors on level-2 (between-participants). This might have led to an underestimation of the relative influence of motivational factors on snacking. Secondly, as with any self-report study, we cannot be assured that participants accurately reported their snacking. Although previous research suggests that it is common that individuals underreport their food and energy-intake (e.g., Heitmann & Lissner, 1995; Johansson et al., 1998), the average number of daily snacks in the current study are similar to those reported in previous studies (e.g., Schüz, Schüz, et al., 2015). Thirdly, the portion size of participants' food was not measured; therefore, estimates of energy-content may be incorrect (Rolls et al., 2002). Fourthly, there was a conceptual discrepancy between the assessment of behavioural pre-potency and behaviour. Pre-potency was assessed in terms the frequently of adhering to daily fruit and vegetable dietary recommendations, which does not necessarily correspond with typical snacking patterns. Similarly, we assessed participants' intention to eat healthier, which likely encompasses food intake outside of snacking. Nevertheless, these constructs provided an indication of past behaviour and intentions to change future behaviour and future studies should modify the assessment questions to focus exclusively on snacking. Further, our assessment of the availability of food might be limited by the logical implication that food has to be present in order to be consumed– and our assessment was not fine-graded enough to measure whether food was present prior to the decision to snack, or whether food was obtained with the purpose to snack. Finally, we did not assess participants' exposure to food-related advertisements which may have served as a cue to eating (Nestle, 2002). Future studies should aim to assess the effect of advertisements as a momentary cue to snacking.

3.5.4 Implications

This study offers new insight into the application of TST in explaining momentary eating behaviours. The focus of the study was to examine how interactions between the person and the environment influence snacking. Our study shows that applying TST to snacking improves our understanding of the momentary and motivational-level variables associated with snacking. The results demonstrate that snacking is largely guided by momentary cues, and that motivational-level factors may be less important in guiding snacking than previously thought. Through examining the temporal aspects of behavioural contingencies, TST allows for greater understanding of why individuals engage in behaviours that have detrimental effects on their health (Cameron, 2010).

With improved understanding of how the two spheres of TST interact to inform human behaviour, we can target interventions accordingly. Working with individuals to increase their self-regulatory skills may enable them to better control their snacking and be less influenced by momentary cues (Annesi & Mareno, 2014; Kitsantas, 2000). This could be achieved through self-monitoring snack consumption (Teixeira et al., 2015), or through using strategies such as implementation intentions or health-goal primes to remind individuals of their eating goals and how to manage triggers in cue-rich situations (Adriaanse et al., 2009; Gollwitzer, 1999; Papies & Veling, 2013; Sellahewa & Mullan, 2015; van Koningsbruggen et al., 2011). Further, health-goal primes operate without an individual's conscious awareness and have been shown to enable individuals to better maintain their goals even situations of depletion (e.g., Sellahewa & Mullan, 2015). The current study findings suggest that interventions need to focus on improving an individual's self-regulatory abilities, but also acknowledge the momentary cues that are associated with the initiation of snacking.

TST is an emerging theory; more evidence is needed to draw conclusions surrounding the momentary influences on eating and how this interacts with eating motivations. Nevertheless, the importance of making individuals aware of their motivational and momentary cues to eating is important to enable them to develop the means to override their eating triggers and focus on developing stronger, healthier eating habits (McKee et al., 2014).

Chapter 4 Situational cues and momentary food environment predict everyday eating behaviour in adults with overweight and obesity[7]

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As stated previously, the present thesis aims to investigate the individual and contextual determinants of discretionary food intake. The previous chapter applied Temporal Self-regulation Theory to eating to explore how both motivational and momentary determinants are associated with discretionary food consumption. This chapter (Study 3) moves further away from the individual in the socio-ecological model, and explores the role of momentary cues in prompting food intake (see Figure 4.1). Here, negative affect, the availability of food, the presence of others eating and being alone, and representations of the environment are explored.

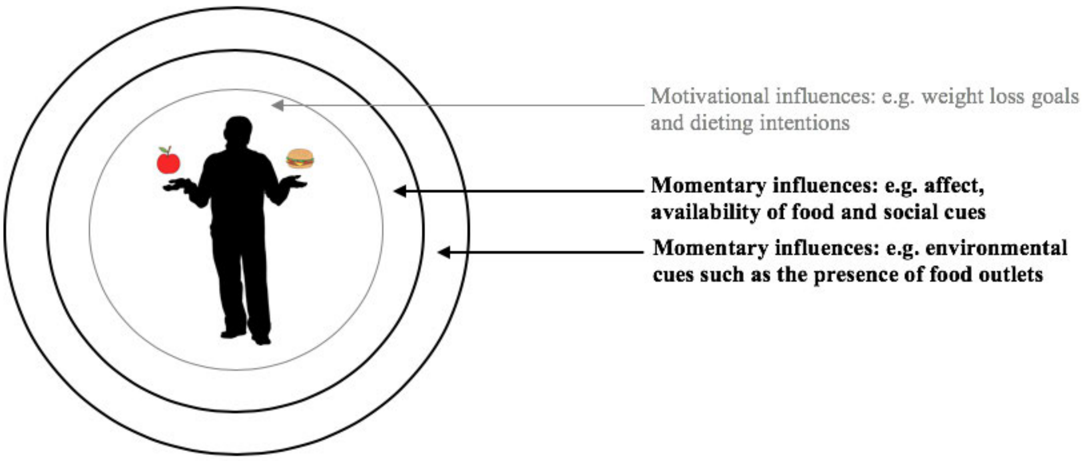

Figure 4.1 Diagram outlining the momentary influences of discretionary food intake examined in Chapter 4.

Extracts of Study 3 have been examined in my Honours thesis. However, substantial changes have been made to the current version of the manuscript. The manuscript has been substantially rewritten and new variables have been analysed. The incorporation of Study 3 is crucial for this PhD thesis as it establishes the need to explore how representations of the environment influence eating behaviour (a key focus of Chapter 5). It establishes a link between goal conflict theory (explored in Chapter 2) and Temporal Self-regulation Theory (examined in Chapter 3). Finally, interventions suggested in this chapter combine both individual and environmental determinants (further explored in Chapter 6).

4.1 Abstract

Objectives: Individual eating behavior is a risk factor for obesity and highly dependent on internal and external cues. Many studies also suggest that the food environment (i.e., food outlets) influences eating behavior. This study therefore examines the momentary food environment (at the time of eating) and the role of cues simultaneously in predicting everyday eating behavior in adults with overweight and obesity.

Methods: Intensive longitudinal study using ecological momentary assessment (EMA) over 14 days in 51 adults with overweight and obesity (average BMI 30.77; *SD*= 4.85) with a total of 745 participant days of data. Multiple daily assessments of eating (meals, high- or low-energy snacks) and randomly timed assessments. Cues and the momentary food environment were assessed during both assessment types.

Results: Random effects multinomial logistic regression shows that both internal (affect) and external (food availability, social situation, observing others eat) cues were associated with increased likelihood of eating. The momentary food environment predicted meals and snacking on top of cues, with a higher likelihood of high-energy snacks when fast food restaurants were close by (OR= 1.89, 95% CI= 1.22, 2.93) and a higher likelihood of low-energy snacks in proximity to supermarkets (OR = 2.29, 95%CI = 1.38, 3.82).

Conclusions: Real-time eating behavior, both in terms of main meals and snacks, is associated with internal and external cues in adults with overweight and obesity. In addition, perceptions of the momentary food environment influence eating choices, emphasizing the importance of an integrated perspective on eating behavior and obesity prevention.

Key words: Food cues, food environment, stimulus control, ecological momentary assessment, obesity

4.2 Introduction

The presence of obesity has risen dramatically across many industrialized countries (Apovian, 2016). Current estimates suggest that, for example in Australia, the context of this study, more than one in four adults is obese (Body Mass Index [BMI] ≥ 30), whereas more than 60% of the adult population are overweight (BMI ≥ 25: ABS, 2015). Obesity is a major public health problem and is associated with a substantially increased risk of chronic illness. A major behavioral risk factor for obesity is food intake, thus research on the determinants of individual eating behavior is paramount.

Theoretical models of eating behavior have evolved from a homeostatic perspective on restoring energy balance to emphasizing the role of individual, social, and environmental cues or stimuli that prompt an individual to eat (Cruwys et al., 2014; Sobik et al., 2005; Weingarten, 1985). In environments that provide sufficient food for the population, the majority of eating behaviors are likely to be guided by both internal and external cues rather than experiencing an energy imbalance (Lowe & Butryn, 2007; Weingarten, 1985). Cue-dependent eating seems to be particularly relevant among individuals who are overweight (BMI> 25) and obese (BMI > 30: Thomas et al., 2011), whereby these individuals experience increased cravings (Ouwehand & Papies, 2010) and physiological responses such as increased salivary reaction (Ferriday & Brunstrom, 2011) in the presence of food cues (compared to individuals in lower BMI ranges). Research on the cues that elicit eating behavior in the population of adults with overweight and obesity is particularly important.

Internal cues include for example stress and negative affect (O'Connor et al., 2008), which have been shown to trigger eating episodes among individuals with obesity (Goldschmidt, Crosby, et al., 2014), potentially motivated by controlling negative affect via the intake of high-energy food (Parker et al., 2006) and the associated reward experience (Small, 2009).

External cues to eating include the availability of food (Schüz, Bower, et al., 2015; Schüz, Schüz, et al., 2015) and social cues (Higgs & Thomas, 2016). Social cues shape dietary behaviors through observation and interactions that occur during meal times. Through observing others eat, a norm of eating is created and limits are set for appropriate food and drink intake (Prinsen et al., 2013). Further, changing eating behavior as a result of observing others eating might suggest a social modelling mechanism (Cruwys et al., 2014; Herman et al., 2003). Conversely, being alone and social isolation have also been associated with increased eating, with this pathway potentially mediated by negative affect (Mason et al., 2016).

A second level of external factors affecting eating behavior opens when the supply or the number, density and variety of food outlets in an individual's surroundings (food environment) is examined (Thornton & Kavanagh, 2012). For example, areas with a higher density of fast-food outlets have been associated with higher levels of fast-food consumption (Lucan & Mitra, 2012). Individuals living in these areas are almost twice as likely to develop obesity than those who live in areas with fewer fast-food restaurants (Fuzhong et al., 2008). Areas with a higher density of fruit and vegetable outlets and supermarkets on the other hand are associated with higher fruit and vegetable consumption and lower prevalence of overweight and obesity (Bodor et al., 2007; Lucan & Mitra, 2012; Morland et al., 2006). This is possibly due to the accessibility of a wider range of fresh foods, low fat and other health options (Thornton & Kavanagh, 2012).

Most previous studies that have examined the relationship between environmental factors and eating have used retrospective assessments, rather than reporting moment-to-moment environmental exposures (Shiffman et al., 2008) that influence eating in real-time (Goldschmidt, Crosby, et al., 2014; Schüz, Bower, et al., 2015; Schüz, Schüz, et al., 2015). Additionally, previous studies have mostly examined predefined geographical areas, such as individual residential addresses. This means that the influences of environments that are relevant to an individual but are outside of their residential address— such as schools, workplaces and shopping environments— have been neglected (Ball & Thornton, 2013). Individuals pass through many environments outside of their home address each day; therefore, when analyzing the influence of environmental cues, it is essential that the frequent movements of individuals is incorporated. The best way to achieve this is through the recording of moment-to-moment environmental exposures of the food environment, that is, assessing which food is available at which outlets to people at each moment. Closer examination of cue-dependency and the environmental determinants of eating could improve our understanding of how individuals navigate an increasingly obesogenic environment (Stok et al., 2015).

To our knowledge, no previous study has examined the effects of the momentary food environment on eating behavior among adults with overweight and obesity. Thus, this study aims at examining the effects of known internal and external cues on eating, in particular affect (Goldschmidt, Wonderlich, et al., 2014; O'Connor et al., 2008), availability of food (Ferriday & Brunstrom, 2011), social influence (Cruwys et al., 2014; Higgs & Thomas, 2016), and social isolation (Mason et al., 2016), whilst simultaneously assessing the effects of momentary perceptions of the presence and types of food outlets (Ma et al., 2013) at the time the decision to eat is being made. As the most commonly used retrospective assessment of cues to health-related behavior is fraught by memory biases (e.g., Hammersley, 1994), this study uses an ecological momentary assessment (Shiffman, 2009), by which participants log eating decisions in close to real time, together with an assessment of the cues present at the moment. By comparing the ratings of cues in these reports with the ratings of cues during randomly timed non-assessments, we can obtain estimates of the effects of cues on eating decisions. Thus, this study aims at integrating the stimulus control and food environment perspectives and examines the influence of both cues and the momentary food environment on real-time eating decisions in adults with overweight and obesity.

4.3 Method

4.3.1 Overview

We used Ecological Momentary Assessment (EMA) methods (Shiffman et al., 2008) to study the eating patterns of individuals with overweight and obesity. For two weeks, participants were asked to carry an Android mobile phone (LG P500) running customized software (HBART; see: www.utas.edu.au/health/research/groups/behavioural-and-situational-research-group-bsrg/hbart) and stripped of original phone functionality to log every time they ate something as well as respond to randomly timed assessments throughout the day. Participants received between 1 and 9 random assessments per day. Eating cues and the momentary food environment were assessed both during the eating logs and the randomly timed assessments. This allowed the presence and intensity of cues between eating logs and random assessments to be compared (Ferguson & Shiffman, 2011). This method is consistent with previous research on eating behavior (Schüz, Bower, et al., 2015; Schüz, Schüz, et al., 2015), and we followed established protocols in familiarizing participants with the use of the assessment technology (Schüz, Bower, et al., 2015; Schüz et al., 2014).

4.3.2 Participants

Fifty-one adults (34 females, 66.67%) aged 19 to 73 (*M*= 31.81, *SD*= 14.87 years) with obesity (*n*= 24, 47.05%) and overweight (*n*= 27, 52.95%) with a BMI average of 30.77 (*SD*= 4.85) from the general population were recruited for this study. The majority of participants were white (*n*= 40; 78.4%), eight participants (15.7%) had an Asian background, and three participants (5.9%) were of Aboriginal/Torres Strait Islander descent. In terms of education, *n*= 25 (49%) had graduated from university, eight (15.7%) reported other tertiary education, and 18 (35.3%) reported less than completed tertiary education. All participants lived in areas classified as urban (ABS, 2011). Recruitment followed a combination of social media and media releases calling for overweight and obese participants for a study on eating patterns. To be eligible, participants had to be over 18 and have a BMI of at least 25, not be currently dieting and not previously be diagnosed with an eating disorder. Participants who completed the study received AU$50 in shopping vouchers. Such compensation has been shown to promote adherence to EMA protocols in related research (Ferguson & Shiffman, 2011). Ethical approval for this study was obtained from the Human Research Ethics Committee (Tasmania), H.0014439.

4.3.3 Procedure

Procedures for this study mirrored those published in previous research (Schüz, Bower, et al., 2015; Schüz, Schüz, et al., 2015). Briefly, participants came to the lab for an initial visit, signed an informed consent form, were asked to fill in a baseline questionnaire assessing sociodemographic information, and received individualized training on how to use an EMA smartphone. Participants then completed 14 days of field monitoring, with one brief visit to the study center after 2-3 days to assess protocol compliance and troubleshoot any potential issues. Participants were instructed to log food into the device each time they began eating (see below for assessment instrument). These eating logs were accompanied with an assessment of internal and external cues (affect, company, availability of food, observing others eat) and the momentary food environment (see below) *at the time participants decided to eat*. At random times during the day (3-5 times per day), participants were additionally asked to answer the same questions about cues and neighborhood food environment. Each report was time-and date-stamped. In addition, participants completed an evening report during which they had the opportunity to log any food they had during the day but could not report in real-time. At the end of the study, participants returned the device, were debriefed and received reimbursement.

4.3.4 Measurement Instruments

Assessment of *affect* focused on negative affect, as negative rather than positive affect has been shown to be a cue to food consumption in previous research (Schüz, Bower, et al., 2015; Schüz, Schüz, et al., 2015). During food logs and random assessments, momentary negative affect was assessed with 6 items based on the circumplex model of affect (Russell, 1980): angry, bored, irritable, stressed, restless, sad, to be answered on a 0-100 slider scale. Cronbach's Alpha of this scale was .86, indicating satisfactory internal consistency.

External cues were assessed by asking participants to indicate in a yes (1)/no (0) format whether "When you decided to eat, were there people eating" (cue: others eat), whether "When you decided to eat, was there food available" (food availability), and whether they were "with others". This assessment of cues has demonstrated external validity in predicting both food choices (Schüz, Bower, et al., 2015; Schüz, Schüz, et al., 2015) and smoking behavior (Ferguson & Shiffman, 2011; Schüz et al., 2014) and mirrors the assessment used in these previous studies.

Perceived *Momentary Food Environment* was assessed using a cultural and EMA adaptation of the outlet presence section in (Ma et al., 2013) questionnaire. Participants were asked to indicate whether they could see or walk within 5 minutes to one or more of the following food outlets: 1 (franchised fast food outlet), 2 (other fast food outlet), 3 (sit-down restaurant), 4 (supermarket or hypermarket), 5 (smaller food shop), 6 (convenience store), 7 (specialty food shop), 8 (chemist or bargain shop). The presence of any of these outlets was coded as 1 (food outlet close), the presence of none was coded as 0 (no food outlet close).

Food reports were assessed following a two-stage procedure: Participants first self-reported whether they had a main meal or snack (Wansink et al., 2010) and were then asked to indicate the foods (fruit and vegetables, starchy foods, fish, chips, meat, meat products, poultry, cheese, sweets or chocolates, ice cream, crisps/savory snacks, cakes/scones/pastry, biscuits) based on the Dietary Targets Monitor (Lean et al., 2003). Snack reports were then classified as "high caloric density" or "low caloric density" based on the food group reported, with "fruit" and "vegetable" considered "low caloric density" and all other groups considered "high caloric density", based on the energy and saturated fat content estimates of this instrument. These momentary food reports have been validated against summary reports in previous research (Schüz, Schüz, et al., 2015).

During both food reports and random assessments, participants were asked if food was available. Consistent with previous EMA research (Thomas et al., 2011), participants were instructed to interpret food being available if it was visible and accessible for them to eat (e.g., having food on the desk at work).

4.3.5 Analyses

Because EMA data has a hierarchical structure in which multiple daily assessments of food reports and randomly timed reports are nested within individuals, multilevel multinomial logistic regression with random intercepts of the dependent variable (food categories) and random slopes of the predictors (cues, neighborhood food environment) was used (Snijders & Boskers, 2012). We first examined all cues, and in a second step examined the role of different food outlet types separately.

These analyses fit individual multinomial logistic regressions in which the likelihood of every assessment to be a meal report (1), a “high caloric density” snack (2), a “low caloric density” snack (3), or a “random assessment” (4) is predicted for every participant (within-participant analysis), and the resulting estimates of these analyses are then pooled while at the same time allowing the base likelihood of any report (random intercept) as well as the effects of the covariates (random slopes) to vary between participants. This procedure obtains both pooled estimates of the overall effects of the covariates and intercepts as well as estimates of the amount and significance of between-person variation in each effect, indicating between-person differences.

4.4 Results

Overall, there were 745 participant days available for analysis. Each participant completed an average of 14 days of monitoring (*M*= 14.61, *SD* = 1.46). Consistent with previous research (Schüz et al., 2014), 11 participant days with poor compliance (defined as answering less than 50% of random prompts) with a total of 17 random prompts and 9 food reports were excluded. This left a total of 1,953 random prompts to be analyzed, of which participants answered 1,861 (average of 2.62 prompts per day), rendering an overall compliance of 95.29%. On average, participants missed 0.12 random prompts (*SD*= 0.37) per day. A total of 1,665 meals, 574 high-energy and 232 low-energy snacks were reported in real time (not including evening reports), averaging to 2.23 meal reports, 0.78 high-energy and 0.31 low-energy snack reports per participant per day, which is consistent with previous research findings (e.g., Schüz, Bower, et al., 2015; Grenard et al., 2013).

Food Cues and Momentary Food Environment

Table 4.1 shows the means of negative affect and the percentages of cues present across the food assessment categories and random prompts. Negative affect was highest during the decision to have a high-energy snack, the percentage of reports of being alone was highest during the decision to have a low-energy snack, food was most likely to be present during the decision to have a low-energy snack, others eating were most likely to be observed during the decision to have a meal, and food outlets were most likely to be present during the decision to have a high-energy snack.

Table 4.1 Means of individual (within-person) means and standard deviations and means of individual (within-person) percentages and standard deviations for internal and external cues across food types.

Cue	Meals	High-energy snacks	Low-energy snacks	Random Prompts
Negative Affect	23.51 (17.04)	25.63 (18.04)	21.94 (20.83)	22.67 (15.90)
Being Alone (%)	40.95% (25.79)	41.99% (34.03)	50.81% (39.63)	42.14% (24.63)
Availability of Food (%)	86.17% (21.07)	91.78% (21.01)	92.87% (19.66)	75.19% (24.77)
Observing Others Eat (%)	48.23% (24.86)	39.30% (30.54)	27.07% (32.68)	16.16% (16.10)
Current Food Environment (Outlet Proximity) (%)	55.25% (36.80)	60.18% (38.42)	55.15% (45.01)	52.71% (37.21)

Note. Negative Affect assessed on a 0 – 100 scale; Percentages are the mean of the individual percentages of reports where the cue was present.

We first estimated the intraclass correlation coefficients (ICC) of the different food categories compared to random prompts in order to examine the need for multilevel multinomial logistic regression in accordance with (Snijders & Boskers, 2012). The ICC of meals compared to random prompt was ρ= .06; the ICC of high-energy snacks compared to random prompts was ρ= .35, and the ICC of low-energy snacks compared to random prompts was ρ= .37, all exceeding the .05 threshold (Hox,

2010) that indicates a substantial amount of variance in the dependent variables to be due to between-participant differences.

In the multilevel multinomial logistic regressions, we first specified all cues and the food environment as predictors of the likelihood of a data point being a food report, a high-energy snack, or a low-energy snack as opposed to a random assessment (see Figure 4.2). We found that all cues apart from negative affect predicted the likelihood of a data point being a *meal* vs. a random assessment, with in particular observing others eat increasing the likelihood more than nine-fold. Being close to a food outlet increased the odds of a meal by 39%. For *high-energy snacks*, negative affect predicted the likelihood against random prompts, with the odds increasing by 2% for every point increase on the negative affect scale. Food outlet proximity increased the odds of a high-energy snack by 64% compared to random assessments. With regard to *low-energy snacks*, all cues, but not food outlet proximity predicted increased odds of such snacks as opposed to random prompts (see Figure 4.2).

The residual variances of all food categories were significant, with meals ($\sigma^2_{u0(1)}$) = 0.10, p < .001; high-energy snacks ($\sigma^2_{u0(2)}$) = 0.68, p < .001, and low-energy snacks ($\sigma^2_{u0(3)}$) = 0.74, p < .001. This suggests that there are substantial differences between individuals with regards to the overall odds of the different food report types (significant variance components in all intercepts). However, significant residual variance was only observed for the slopes of cues in predicting meals vs. random prompts, and in the slopes of food outlet proximity in predicting high-energy snacks, which suggests that participants differed with regards to the effects of these covariates.

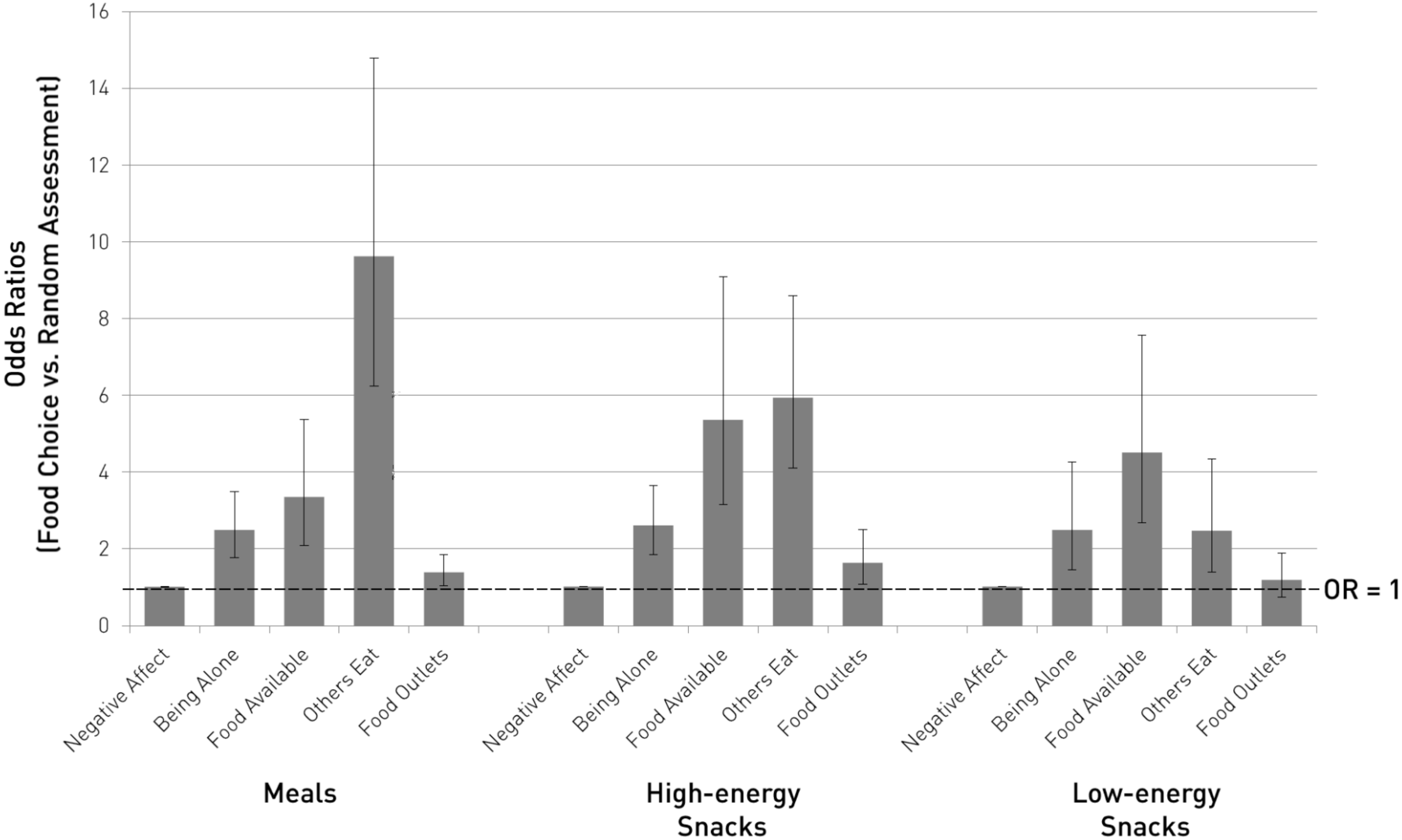

Figure 4.2 Odds ratio of cues and momentary food environment (food outlets) in predicting food choices.

4.4.1 Momentary food Environment – Types of Outlets

In the second step, we compared the presence of different food outlets during the decision to eat (see Table 4.2), and then examined the effects of different kinds of food outlets on the odds of the different food reports in a second set of multilevel multinomial logistic regressions. Here, we specified the presence of “fast-food” outlets (both franchised and other), “restaurants”, “shops” (including both supermarkets and specialty shops) and “convenience” (including both convenience stores and bargain/chemists) as predictors of the odds of any measurement point being a meal report, a high-energy snack, a low-energy snack, or a random assessment (reference category). Figure 4.3 shows the Odds Ratios (OR) of the different kinds of food outlets and suggests that for meals, no specific food outlet was associated with a higher likelihood as compared to random prompts. However, the odds of *high-energy* snacks are significantly increased (by 89%) if a fast-food outlet is close by, whereas the odds of a *low-energy* snack are significantly increased when a supermarket or specialty food shop is close by (129%) compared to random assessments.

Table 4.2 Means of individual (within-person) percentages and standard deviations for perceived proximity of food outlet types across food types.

Food Outlet Type	Meals	High-energy snacks	Low-energy snacks	Random Prompts
Restaurant (%)	37.69% (34.85)	42.61% (40.06)	42.88% (44.85)	37.62% (34.69)
Fast Food Outlet (%)	39.93% (35.38)	45.73% (40.30)	44.10% (46.57)	39.02% (35.17)
Convenience Store (%)	40.19% (38.11)	42.02% (38.99)	37.86% (45.19)	39.12% (38.06)
Shop (%)	42.79% (38.69)	47.65% (40.92)	45.49% (44.79)	42.51% (38.58)

Note. Percentages are the mean of the individual percentages of reports where the cue was present.

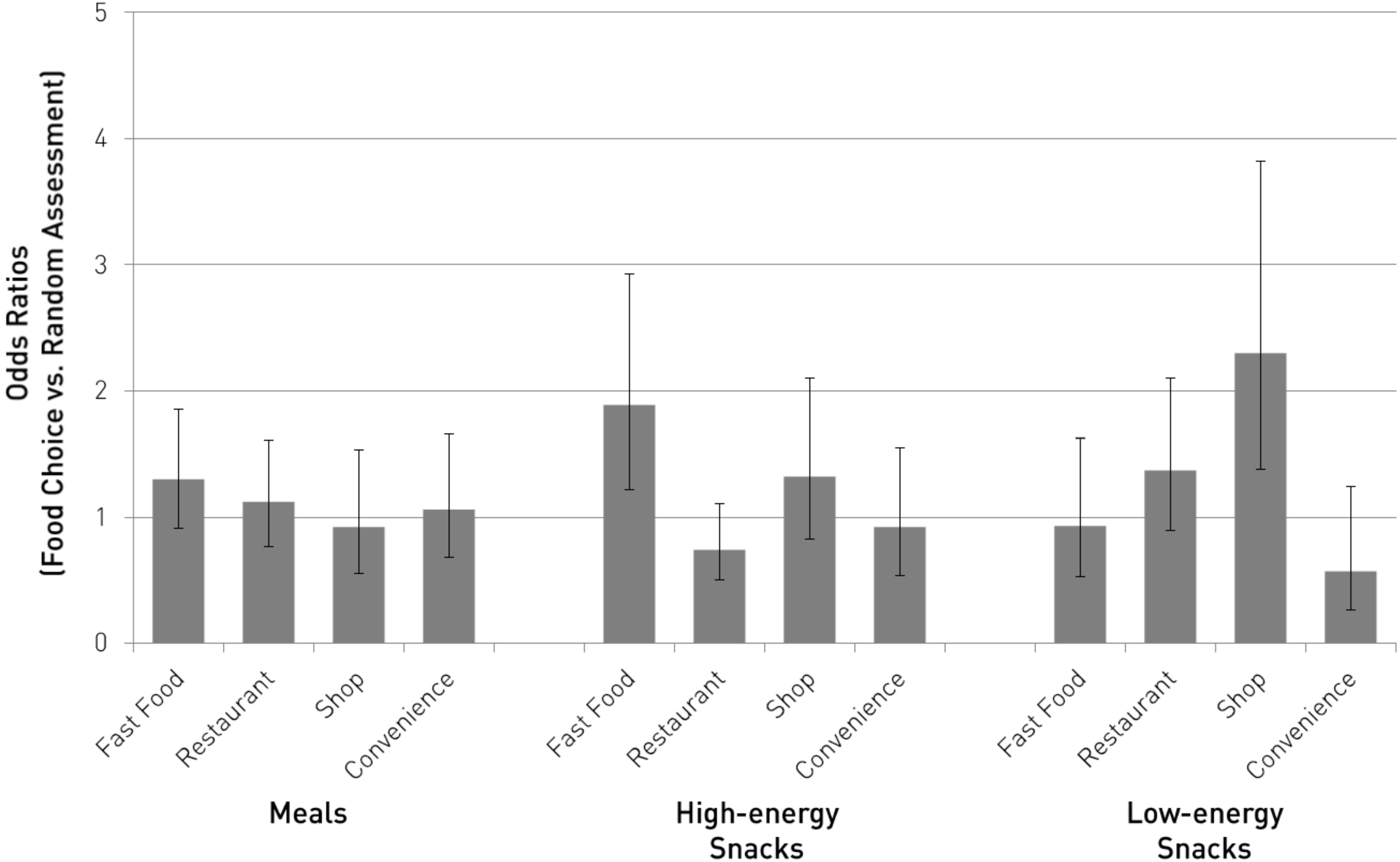

Figure 4.3 Odds ratios of different food outlets in the momentary food environment in predicting food choices.

4.5 Discussion

This study examined the effects of internal and external cues as well as perceptions of the momentary food environment on everyday eating behavior in adults with overweight and obesity. Two sets of analyses were run, one examining the role of the perceived momentary food environment in the context of known internal and external cues to eating, the second set examining which kinds of food outlets in the momentary food environment were related to specific food choices. Regarding the first set of analyses, we found that negative affect increased the likelihood of snacking, the availability of food and observing others eat increased the likelihood of eating, and finally, perceiving food sources to be nearby had increased the likelihood of meals and high-energy snacks occurring when all other predictors were accounted for. In the second set of analyses, we examined the effects of specific food outlet types and found that perceived proximity to fast food outlets increased the odds of high-energy snacks, whereas proximity to supermarkets and specialty food shops increased the odds of low-energy snacks when compared to randomly timed assessments.

Previous studies have demonstrated that the neighborhood food environment is associated with individual eating behavior (Bodor et al., 2007; Fuzhong et al., 2008; Lucan & Mitra, 2012), but our study additionally suggests that people consider the momentary presence of food outlets as they make the decision to eat. The finding that the effects of the momentary food environment differed between high- and low- energy snacks is particularly relevant, as discretionary food choices (snacks) have been shown to account for up to 35% of the daily energy intake in Australian adults (ABS, 2015). While it is important to note that our study assessed perceptions of the availability of food, which might not exactly map on the actual presence of food retailers (Barnes et al., 2015), this finding nevertheless suggests that perceiving food outlets to be close can predict both eating meals and— with a more substantial effect size— high-energy snacks.

We also found that there are differential effects of different types of food outlets on eating behaviors (see Figure 4.3). The likelihood of a meal occurring did not differ between types of food outlets, however, the perceived proximity of fast food outlets was associated with a higher likelihood of high-energy snacks. Furthermore, the presence of shops (defined as shops with a full range of groceries as opposed to convenience stores) was associated with an increased likelihood of low-energy snacks. It has to be noted that both assessments had a lower base likelihood than the random assessments they were compared with, so it is possible that singular events have led to an overestimation of these effects. Nevertheless, these effects are in line with previous research that has shown that specific food outlets influence different types of eating behavior (Bodor et al., 2007; Lucan & Mitra, 2012). Our research extends this intersection of behavioral and spatial research with a real-time perspective, which demonstrates the food environment impacts on people's real-time eating decisions.

This has some important implications both for theories of eating behavior as well as for the development of potential interventions. In terms of theories, our data provides evidence that the food environment is associated with individual food choices, particularly, discretionary food choices. Integrating this in theories of eating behavior such as the goal conflict model of eating (Stroebe, Mensink, et al., 2008) or theories of health behavior that incorporate situational aspects such as Temporal Self-Regulation Theory (Hall & Fong, 2007) suggests that representations of the environment can influence eating-related behavioral activation processes. In terms of the potential of our findings to inform intervention development, the finding that the food environment shapes individuals eating decisions suggests that environmental planning and regulation of food outlets may be a viable option to modify population diet, and that behavioral interventions should take the momentary food environment into account, for example in prompting implementation intentions (O'Connor et al., 2015).

The finding that negative affect increases the likelihood of snacking replicates previous findings from individuals with a BMI within the normal-weight range (O'Connor et al., 2008; Schüz, Bower, et al., 2015). Furthermore, it speaks to the notion of ‘comfort eating’, that is, eating in order to regulate negative affect (Parker et al., 2006). However, while previous research has emphasized that negative affect and stress increases the likelihood of choosing energy-rich foods (O'Connor et al., 2008; O'Connor et al., 2015), our study suggests that, at least in a sample of adults with overweight and obesity, negative affect increases the likelihood of both high and low-energy snacks. We think that this at least partly due to expectations regarding the mood-regulating effects of food (Raspopow et al., 2013). Nonetheless, affect-regulative rewards associated with eating might be a conditioned response of the individual (Berridge et al., 2010), but is subject to substantial individual differences (Sproesser et al., 2014). Individual differences such as susceptibility to food-related stimuli (Power of Food: Lowe et al., 2009) can explain some of these differences in the effects of negative affect (Schüz, Schüz, et al., 2015).

This study found the presence of others eating and being alone to be significantly associated with an increased likelihood of both eating and snacking, a finding which is consistent with previous research in this area (Schüz, Bower, et al., 2015). Participants were more likely to eat a meal or snack when they observed others eating. Apart from societal norm effects that make it more likely that main meals are consumed with e.g., the family, the effects of observing others eat on consuming snacks could also be due to modeling (Cruwys et al., 2014; Higgs & Thomas, 2016) or the implicit creation of an eating norm (Herman et al., 2003; Prinsen et al., 2013). In both instances, observing others eat would suggest to an individual that it is appropriate to eat. The finding that being alone increased the likelihood of consuming all types of food could be due to the established effects of social isolation on eating (Mason et al., 2016), or to a generally higher likelihood of eating when alone (Higgs & Thomas, 2016). However, our data did not allow disentangling whether eating when alone functioned a mood-regulation effect, which would be implied in the idea of increased eating when socially isolated.

The finding that food availability is significantly associated with all types of eating is also in line with previous research (Ferriday & Brunstrom, 2011) that showed that being exposed to food increased subjective experiences of hunger and desire to eat. When looking at the effect sizes of food availability, it becomes apparent that this factor is more strongly associated with consuming snacks than meals; probably an artifact of the meal situation, which is more likely to take place in a food-rich environment such as one's home (Emery et al., 2015), therefore reducing systematic variance in this factor between random assessments and eating reports. On the other hand, this finding suggests that having food available can trigger snacking behavior, which would speak towards cue control-type interventions that require individuals to remove foodstuffs from their environment in order to reduce discretionary eating behavior (Greenwald, 2006). The significant variance components of the random intercepts further suggest there are individual differences in the effects of the food environment on the odds of snacks– which in turn suggests people differ in how the momentary food environment affects their eating.

4.5.1 Strengths, limitations and future directions

A key strength of this study is that it uses EMA to consider the role of the momentary food environment on food choices. EMA research enables real time reporting of eating behaviors, thereby reducing recall-biases associated with food diaries or questionnaires (Heitmann & Lissner, 1995; Thomas et al., 2011).

Nevertheless, the study remains a self-report study, without objective assessment of eating behavior. However, a full objective assessment of eating is less practical when everyday behavior is of interest.

The assessment of perceived food environment could be considered a limitation, and future studies should consider integrating real-time EMA data with geographic information-based data on the food environment. In addition, future studies should consider the effect of both food advertisements and how the layout of food stores could influence individuals' consumption practices (Nestle, 2013).

The relative burden of an EMA study limits the reach and sample size and thus the generalizability of our results. However, previous simulation studies (Maas & Hox, 2005) suggest that sample sizes such as the one in this study are sufficient to obtain reliable estimates of the within-person processes. This study was not powered to examine between-participant differences in the effects of food cues, and future, larger studies might consider examining between-person differences in the within-person effects of cues and environment. These seem plausible, since there is evidence for differential effects of food cues among individuals who are overweight compared to those within the normal BMI range (Ferriday & Brunstrom, 2011; Ouwehand & Papies, 2010), and between participants high and low in psychological characteristics such as self-control (Hofmann et al., 2014), or the Power of Food Scale (Schüz, Schüz, et al., 2015), possibly due to individual neurophysiological differences in the reward system (Small, 2009).

A limitation pertains to the fact that we did not measure the portion size of foods that were consumed. This could impact on the validity our classification of foods into high- and low-energy snacks, as the energy content will vary with portion size. Furthermore, our classification of foods in general lacks detail, but a more differentiated assessment would have impacted on participant burden. Future studies could integrate new technology allowing a more detailed assessment of caloric and nutrient content (e.g., taking photos of the meal / snack) in order to replicate these findings.

To reduce participant burden, this study has relied on a very limited selection of food cues, and known situational predictors of eating behavior such as daily hassles (O'Connor et al., 2008) and state hunger (Witt et al., 2014) were not assessed in this study. Further, this study did not examine the role of food advertisements as cues for food choices. Food advertisements are key cues to buying, and subsequently eating, certain food products (Nestle, 2002; Nestle & Jacobson, 2000). Often advertisements pair food with rewarding outcomes, which increases an individual's desire to consume such products even after limited exposure to the advertisements (Pollard et al., 2002; Sobik et al., 2005; Watson et al., 2016). Advertisements that employ health claims further increase the sales of such products (Nestle et al., 1998).

Food advertisements are also influential in shaping community dietary intake, and there are substantial neighborhood differences in the types of foods that are advertised within various communities. This difference can largely be explained by the socioeconomic status of the neighborhood: There are more advertisements for unhealthy foods in neighbourhoods with lower compared to neighborhoods with higher socioeconomic status (Lorenc et al., 2013). Through not assessing the number and type of food advertisements participants experienced, we may have underestimated the influence of the food environment on individuals' food choices, and future research should include momentary assessments of the effects of food advertisements.

Lastly, we did not gather information on the layout of food stores, which have been shown to differ between socioeconomic neighborhoods (Moore et al., 2008) and ultimately shape the purchasing behavior of individuals within such neighborhoods (Morland et al., 2006). Future research examining the influence of cues on eating behaviors should continue the approach we have taken, and combine it with assessments of individuals' awareness of advertisements within their surroundings.

4.6 Conclusion

To conclude, this study shows the influence of the momentary food environment on eating behavior among adults with overweight and obesity. It shows the food environment effects individual eating behavior even when considered simultaneously with known situational and individual cues to eating such as social situation or affect. This has important implications for both theory and intervention development among adults with overweight and obesity, since it suggests that interventions to modify eating behavior should combine individual-level interventions targeting eating cues and environment-level interventions targeting the placement and density of different types of food outlets (Hillier-Brown et al., 2014).

Chapter 5 Comparison of Geographic Information System and subjective assessments of momentary food environments as predictors of food intake: An Ecological Momentary Assessment Study[8,9,10,11,12]

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[8] Initial findings from this chapter were presented at an international conference: Elliston, K. G. & Ferguson, S. G. (2018, August 23). Examining the association between food outlets and eating behaviour: A Geographic Information System (GIS) study. Paper presented at the European Health Psychology Society conference, Galway, Ireland. (see Appendix 5.1 for Abstract).

[9] Extracts from this chapter were presented at an international conference: Elliston, K. G., Schüz, B. & Ferguson, S. G. (2019, September 4). Objective (GIS) and subjective food environment as predictors of momentary food intake. Paper presented at the European Health Psychology Society conference, Dubrovnik, Croatia. (see Appendix 5.2 for Abstract).

[10] This chapter has been published in its current form as: Elliston, K. G., Schüz, B., Albion, T., & Ferguson, S. G. (2020). Comparison of Geographic Information System and Subjective Assessments of Momentary Food Environments as Predictors of Food Intake: An Ecological Momentary Assessment Study. *JMIR Mhealth Uhealth, 8*(7), e15948. https://doi.org/10.2196/15948

[11] The EMA questionnaire used this study is included in Appendix 5.3.

[12] The Baseline questionnaire used this study is included in Appendix 5.4.

The overall aim of the present thesis is to investigate the individual and contextual determinants of discretionary food intake. The previous chapter explored how contextual determinants such as negative affect, the availability of food, the presence of others and representations of the environment influence momentary eating decisions. This chapter further explores the distal level of influence in the socio-ecological model; environmental determinants of eating (see Figure 5.1). Here, we explore whether objectively collected location information through automatic GPS reports predict eating beyond subjectively reported environmental cues.

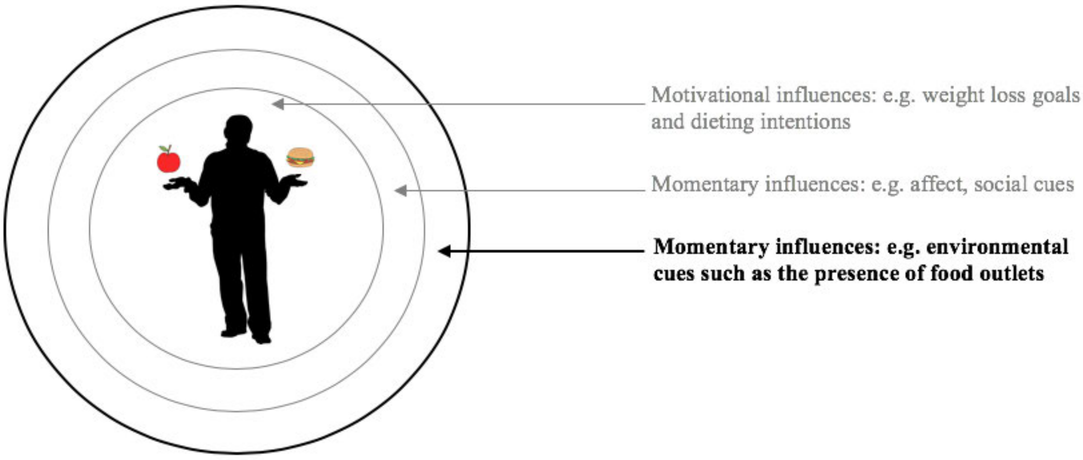


Figure 5.1 Diagram outlining the momentary influences of discretionary food intake examined in Chapter 5.

5.1 Abstract

Background: It has been observed that eating is influenced by the presence and availability of food. Being aware of the presence of food in the environment may enable mobile health (mHealth) apps to use geofencing techniques to determine the most appropriate time to proactively deliver interventions. To date, however, studies on eating typically rely on self-reports of environmental contexts, which may not be accurate or feasible for issuing mHealth interventions.

Objective: This study aimed to compare the subjective and geographic information system (GIS) assessments of the momentary food environment to explore the feasibility of using GIS data to predict eating behaviour and inform geofenced interventions.

Methods: Seventy-two participants recorded their food intake in real-time for 14 days using an ecological momentary assessment approach. Participants logged their food intake and responded to approximately 5 randomly timed assessments each day. During each assessment, the participants reported the number and type of food outlets nearby. Their electronic diaries simultaneously recorded their GPS coordinates. The GPS data were later overlaid with a GIS map of food outlets to produce an objective count of the number of food outlets within 50 m of the participant.

Results: Correlations between self-reported and GIS counts of food outlets within 50 m were only of small size (r=0.17; P<.001). Logistic regression analyses revealed that the GIS count significantly predicted eating similar to the self-reported counts (area under the curve for the receiver operating characteristic curve [AUC-ROC] self-report=0.53, SE 0.00 vs AUC-ROC 50 m GIS=0.53, SE 0.00; P=.41). However, there was a significant difference between the GIS-derived and self-reported *counts* of food outlets and the self-reported *type* of food outlets (AUC-ROC self-reported outlet type=0.56, SE 0.01; P<.001).

Conclusions: The subjective food environment appears to predict eating better than objectively measured food environments via GIS. mHealth apps may need to consider the type of food outlets rather than the raw number of outlets in an individual's environment.

Key words: Ecological Momentary Assessment; mHealth; Geographic Information Systems; food intake; mobile phone

5.2 Introduction

Consistent with the notion of stimulus control, momentary environments are key correlates of a range of health-risk behaviours. For example, studies have shown associations between exposure to smoking-friendly environments and smoking (Jahnel et al., 2017), being in an abandoned space and illicit drug use (Linas et al., 2015) and being closer to fast-food outlets and an increase in discretionary food intake (Elliston et al., 2016). As such, being aware of what is in an individual's momentary environment could provide a means for issuing just-in-time adaptive interventions (Naughton, 2016). For example, when entering environments known to trigger health risk behaviours, mobile health (mHealth) technology could generate interventions and support to individuals (Donker et al., 2013), thereby minimizing the risk of engaging in health-damaging behaviours (Nahum-Shani et al., 2014).

However, for effective, just-in-time, and geofenced intervention designs, it is crucial to know the components of momentary environments that are most reliably related to risk behaviours. In particular, it is an open question whether the subjective perceptions (e.g., the number of food outlets an individual perceives as close by) or the objective indicators of food environments (e.g., a geographic information system [GIS]–based count of the number of food outlets in a given radius around an individual) are more reliably associated with health risk behaviours, such as high-calorie snacking.

Previous real-time studies have typically favoured self-reported measures, requiring a user to manually input details surrounding their affect, activities, and environment (Jahnel et al., 2017; Elliston et al., 2016; Duresso et al., 2018). For example, many studies ask participants to indicate their current environment from several prespecified locations (e.g., work, home, restaurant or bar). Intensive self-report is desirable in the context of research studies, but such monitoring is burdensome and, hence, likely to be unfeasible for the long-term usage that is necessary to achieve a lasting behavioural change. Although self-reported data might generate richer data sets, for example, by allowing researchers to gather data on unobservable psychological processes and motivations, this needs to be balanced against the possibility of missing data through noncompliance with monitoring protocols. Another option is to passively monitor an individual's environments using location, movement, or biometric sensors. In the case of location, for example, this could be achieved by combining GPS data from individual devices with GIS data, which could then be used to create targeted geofence-based mHealth interventions. Being passive, such monitoring is likely better suited for long-term monitoring than relying on self-reported information.

Passive monitoring, however, is not without its potential drawbacks. Of particular concern is that passively collected GPS data and self-reported data may capture differential aspects of the environment that might be relevant for behaviour change. For example, although passive monitoring may be objectively accurate, individuals may not always be aware of— or influenced by— cues in their surrounding environment. It is possible that being actively aware of environmental cues is crucial to the initiation of health risk behaviours; therefore, passively monitoring locations may not be an appropriate way to target context-sensitive interventions. Indeed, some studies explicitly ask individuals to report on their behavioural triggers using a *cues to action* scale (Booker & Mullan, 2013; Todd & Mullan, 2014), thereby implying that the individuals are aware of the environmental cues that trigger their behaviour. Previous environmental interventions have been shown to improve health behaviour, such as food safety behaviours (Mullan et al., 2014), suggesting that consciously perceived cues can trigger behaviours. However, other behaviours, such as eating, maybe prompted by the automatic processing of environmental cues, such as advertisements and brand logos (Cohen & Babey, 2012; Kremers et al., 2006). This is consistent with stimulus control theory as it does not specifically require conscious awareness of cues. Therefore, in this study, we obtained both passive and active measures of the environment and compared the associations of both with food choices, a behaviour shown to be influenced by environmental cues (Elliston et al., 2016; Pitt et al., 2017; Cannuscio et al., 2013; Trapp et al., 2015). Comparing potentially different effects of passive and actively collected location information will allow us to examine the automatic and deliberate processing of cues that may prompt individuals to eat.

Although the role of environmental determinants on eating behaviour has been previously examined (Fuzhong et al., 2009; Thornton & Kavanagh, 2012; Zenk et al., 2009), these studies typically conceptualize a static notion of the environment by relying on postcode information to calculate estimates of food outlets— which can be viewed as a proxy measure for food availability— in the neighbourhood food environment corresponding to the residential address of a particular person. However, each day, people move between different neighbourhoods and do not always shop in their residential areas (Chaix et al., 2012; Thornton et al., 2017). Therefore, studies need to consider environmental food exposures using individuals' daily travel patterns (their *activity space* (Zenk et al., 2011). On the other hand, studies that examine fluctuating environmental exposures have captured the food environment using self-reported measures (Elliston et al., 2016; Zenk et al., 2011). However, with developments in technology, it is increasingly possible to use GIS data to provide an objective measure of the environments to which individuals are exposed to throughout the day.

5.2.1 Objectives

As ecological momentary assessment (EMA: Shiffman, 2009) allows for real-time assessment of an individual's environment, it might be a particularly useful technique for examining environmental exposures to food intake. This study, therefore, used EMA to examine the GPS coordinates of individuals as they go about their daily lives. As previous studies have supported the role of environmental cues prompting eating, this study aimed to extend this work by investigating whether objectively collected information on momentary environmental exposures (through automatic GPS reports) predict food intake as effectively as subjectively reported environmental cues.

5.3 Method

5.3.1 Overview

This study was a part of a larger project designed to examine the relationship among attentional bias, stimulus control, and obesity and to explore BMI-related differences among individuals' eating behaviours (https://osf.io/pmxbj/). It used EMA methods to explore the feasibility of using GIS data to predict snacking. The participants carried a study-issued smartphone for 2 weeks to self-report their food and drink intake in real-time and respond to randomly timed prompts throughout the day (see *Measurement Instruments* below, for assessment details). During assessments, participants self-reported on environmental exposures, including describing the number and type of food retail outlets nearby. In addition to these self-reported responses, the smartphone logged the participants' GPS locations. The participants' GPS locations were then overlaid on a GIS map of known food outlets. Thus, the study obtained both objective (GIS) and self-reported information about the participants' environment at each time point. A comparison of the environments logged in the food reports with random prompts allowed for the examination of environmental cues to eating.

5.3.2 Participants

Seventy-nine participants were recruited for this study by looking at everyday food choices through social media advertising and a university staff newsletter in

Tasmania. The eligibility criteria included being above 18 years of age, not currently dieting, and having no history of an eating disorder. BMI was stratified to obtain equal groups of participants in the healthy weight range (BMI ≥18.5-24.9) and the overweight and obese (BMI ≥25) range. Upon the completion of the study, the participants received an Australian dollar $60 (United States dollar $39.3) shopping voucher as reimbursement for their time. Ethics approval was obtained from the Tasmanian Social Science Human Research Ethics Committee (reference number H0017015).

Five participants were excluded from the study because of screening scores exceeding 20 on the Eating Attitudes Test (EAT-26: Garner & Garfinkel, 1979), indicating concerns regarding body weight, shape, and eating (Figure 5.2). In addition, 2 more participants were removed (1 participant was removed because of technical issues with his or her electronic device resulting in missing GPS stamps and 1 participant withdrew from the study). This left a total of 72 eligible participants, 71%were females (51/72; mean age 33.72 years, *SD* 12.08). BMI ranged from 18.59 to 40.22 (mean 26.67, *SD* 5.62). Most participants (86%, 62/72) were White. Over half, (60%, 43/72) of the participants had graduated from university, and 28% (20/72) participants had completed at least some university or were currently studying at a university. All participants lived in areas classified as urban (ABS, 2011).

5.3.3 Procedure

Participants attended 3 study visits during the 14-day monitoring period. During the first visit, participants provided informed consent, were weighed, and their height was measured by study staff to calculate their BMI (kg/m^2). Participants also completed a baseline survey assessing demographic information and their general dietary intake and received training on how to use the electronic diaries. Participants began recording their food intake; situational cues, such as their environment; and their affect levels immediately after this visit. During the participants' second visit (around day 2-3 of monitoring), participants' EMA data were uploaded and retraining was provided as necessary. During the third visit, after 14 days of monitoring, participants returned their study devices, were debriefed, and received reimbursement for their participation.

For the duration of the 2-week monitoring period, participants logged their food and drink intake and responded to the randomly timed prompts using a specially programmed smartphone. To reduce the participants' burden, a random subsample (approximately 60%) of the food reports was followed by a set of questions assessing perceptions of the local food environment and contextual cues, such as the participants' affect level and food cravings. In addition to the food reports, participants were issued a series of randomly timed prompts, occurring approximately 4 to 5 times per day. During the randomly timed prompts, participants received the same assessment questions as the food reports. The randomly timed prompts served as a comparison of situational and contextual details regarding eating vs noneating times. All the participants' reports were time, date, and geographically stamped using a combination of GPS and mobile phone transmitter triangulation. Participants received an AUD $60 shopping voucher upon completion of the study and the return of their EMA device, but they were not given additional payment for completing the randomly timed prompts.

5.3.4 Measurement instruments

Food intake was measured via participants' self-reports. Participants reported— by tapping a button on the Android device— whether their food intake was a main meal or a snack.

Current environmental exposures were assessed via both subjective (self-reports) and objective reports (GPS stamps with subsequent GIS integration)— collected during participants' randomly timed prompts and food reports. For the *self-*

reported food outlets, participants were asked to report the number of food outlets nearby. Participants were presented with the question, “From where you are now, how many food outlets can you see?” Then, they were given a list of 6 types of food outlets: (1) fast-food and takeaway stores, (2) restaurants and cafes, (3) supermarket and corner store, (4) specialty food stores, (5) discount stores, and (6) other. Participants entered a number ranging from 0 to 5+ corresponding to each type of food outlet nearby (total possible range 0-30+). For model 2 in the analysis, the total number of self-reported food outlets within sight were summarized. For model 3 in the analysis, each self-reported outlet type was dichotomized (0=absent and 1=present), and all outlet types were simultaneously entered into the model.

For the *objective measure of food outlets*, the participants’ electronic devices automatically recorded their GPS coordinates every time they completed a report. The GPS location for each outlet and the participants’ locations were first split into latitude and longitude coordinates. The distance between the participants and the food outlets was calculated by overlaying their GPS coordinates with a combination of 3 local city council food outlet maps using Environmental Systems Research Institute’s ArcMap (ESRI, 2019). Local council food outlet maps were obtained, with each council providing the outlets’ names, addresses, and type of each food outlet. The councils classified food outlets as being a bakery, butcher shop, café, canteen, caterer, delicatessen, eatery, fish shop, food van, hotel, meat premises, restaurant, sports club, supermarket, takeaway, vessels selling food, or other. However, the classification of food outlets was not consistent across councils, which means that the study was unable to separate food outlets into venue types. As a result, this study used an indicator of any food outlet near participants for analyses. Using council-reported latitude and longitude coordinates of local food businesses, food outlets within a 50m radius of a participant’s GPS location were identified using the Buffer tool from the Analysis Tools Proximity toolbox (ESRI, 2019). The number of food outlets near a participant at the time of each report was then summarized and used in the analyses using the GIS measures.

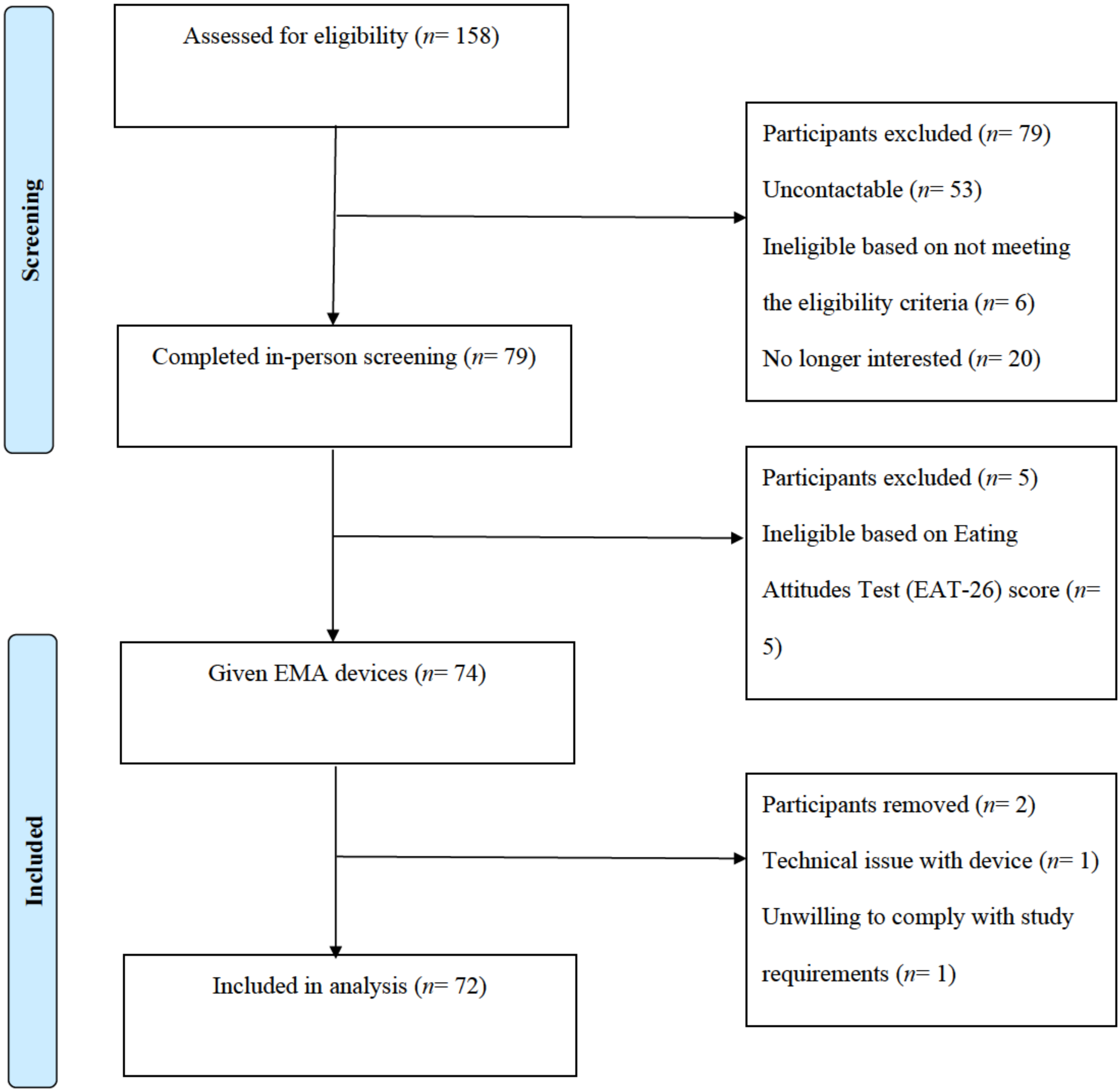
5.3.5 *Analytical Procedure*

To examine whether passively collected GPS reports correspond to the self-reported food environment measures, a repeated measures correlation between the GIS-derived counts and self-reported counts of nearby food outlets was calculated using the R package rmcorr (Bakdash & Marusich, 2017). Next, both GPS-derived food outlet and self-reported food outlet measures were used in participant-level logistic regression models to determine if the number of food outlets within the immediate environment discriminated between eating and noneating reports. Consistent with previous studies (e.g., Schüz, Bower, et al., 2015), the days on which random prompt compliance was below 50% were excluded from the analysis (total 145 days). Poor random prompt compliance may indicate instances of disengagement from the study protocol or systematic biases within the data and are, therefore, removed from further analysis.

While accounting for individual differences in eating, logistic analyses were conducted on each participant's data to gauge the effect of the local food environment on food intake. First, a series of within-subject univariate logistic regression models using the area under the curve for the receiver operating characteristic curve (AUC-ROC) analyses were run. During the randomly timed assessments, each model examined if the odds of eating were higher when the density of food outlets was higher. For each model, food intake (yes or no) was the outcome variable and environmental measures (1) 50m GIS food outlet count, (2) self-reported food outlet count, and (3) self-reported food outlet type were predictors. The study chose 50m as it was a rough approximation of the line of sight typical for urban settings; thus, this radius was deemed as a reasonable approximation of the self-reported measure. AUC-ROC values can range from 0.5 (random guessing; no prediction) to 1.0 (perfect prediction), indicating the probability of identifying an eating event (vs. a randomly timed prompt).

After generating an AUC-ROC for each participant for models 1 to 3 of the environment, the mean for each model was compared with 0.5 (i.e., no predictability, at $p<.05$ threshold) using weighted *t* tests. This was used to determine the environmental measures that could accurately differentiate between eating and noneating (i.e., randomly timed) assessments. Observations were weighted by the inverse of the *SE* of the AUC-ROC scores to allow more precise estimates to receive greater weight (Bradley, 1997; Shiffman et al., 2015). If the AUC-ROC score was significantly different from 0.5 at the $p<.05$ threshold, the model was able to accurately differentiate between eating instances and randomly timed prompts.

Next, 3 *t* tests were run to compare the food count models with each other and compare each count model with the self-reported outlet type. The *t* tests used each participant's AUC-ROC score for the comparisons. Bonferroni adjustments were applied (at $p=.02$ level) to account for the inflation of type 1 errors with multiple comparisons. Finally, the correlations between GIS-derived measures and the self-reported measures were analysed. This enabled the determination of the passively collected (i.e., GIS-derived) environmental information was comparable to the environmental exposure information generated through self-reports. In addition, the counts between GIS-derived assessments of the food environment for both 50m and 100m surrounding an individual were compared, and the same basic outcomes were found. The results of the 50m GIS count of only food outlets are presented below. All analyses were conducted in R version 3.3.1.


Screening
Assessed for eligibility (n= 158)
Participants excluded (n= 79)
Uncontactable (n= 53)
Ineligible based on not meeting the eligibility criteria (n= 6)
No longer interested (n= 20)
Completed in-person screening (n= 79)
Participants excluded (n= 5)
Ineligible based on Eating Attitudes Test (EAT-26) score (n= 5)
Included
Given EMA devices (n= 74)
Participants removed (n= 2)
Technical issue with device (n= 1)
Unwilling to comply with study requirements (n= 1)
Included in analysis (n= 72)

5.4 Results

5.4.1 *Overview*

Seventy-two participants completed between 3 and 21 days of EMA monitoring and were retained in the analysis: mean 14.74 (*SD* 2.58) monitoring days per person. In total, 1061 days of food intake and the immediate food environment were recorded. GIS measures recorded 2097 food outlets within a 50m radius of the participants, and the participants self-reported a total of 1756 food outlets. Over the monitoring period, participants completed 3302 food reports, and 36.86% (1217/3302) of those were snacks. Participants reported between 2 and 10 food intakes (meals and snacks) per day (M= 4.42, *SD* 1.47). The snack intake ranged from 1 to 8 (M= 2.02, *SD* 1.24) per person per day. Participants received between 0 and 11 randomly timed assessments each day (M= 3.28, *SD* 1.73), and the compliance with the randomly timed assessments ranged from 35% to 100%. Overall, the compliance with the randomly timed assessments was excellent (Schüz et al., 2014), where M= 78.75% (*SD* 14.75).

5.4.2 *Geographic Information System-derived measures of food outlets*

The GIS-derived AUC-ROC values ranged from 0.50 to 0.87 and yielded similar AUC-ROC values for the self-reported food outlet count (AUC-ROC for 50m GIS food outlet count=0.53, *SE* 0.00; AUC-ROC for the self-reported food outlet count=0.53, *SE* 0.00; Figure 5.3). Weighted t tests showed that the GIS-derived model had AUC-ROC values significantly higher than 0.50 (the null value; p<.001), indicating that the presence of food outlets within a 50m radius of an individual is significantly better than chance at discriminating between eating and noneating instances.

5.4.3 *Self-reported measures of food outlets*

The AUC-ROC values for the self-reported count of the number of food outlets within sight ranged from 0.50 to 0.62 and had a similar AUC-ROC value for the 50m GIS count (AUC-ROC for the self-report food outlet count=0.53, *SE* 0.00; AUC-ROC for the 50m GIS food outlet count=0.53, *SE* 0.00; Figure 5.3), indicating that both measures of food outlets in the environment are significant predictors of food intake. Results from a paired sample *t* test showed no significant difference between the 50m GIS count and the self-reported food outlet count on the participants' AUC-ROC scores: t_{71}=0.82, *P*=.41, and *d*=0.00.

The AUC-ROC for the self-reported type of food outlets in the environment ranged from 0.50 to 0.75. Model 3 showed that the self-reported type of food outlet was also a significant predictor of eating (AUC-ROC=0.56; Figure 5.3). A paired sample *t* test showed that there was a significant difference between the 50m GIS model and the type of food outlets on the participants' AUC-ROC scores: t_{71}=−2.71, *p*<.001, and *d*=0.40. Similarly, there was a significant difference between the self-reported food outlet count and the type of food outlets on the participants' AUC-ROC scores: t_{71}=−5.16, *P*<.001, and *d*=0.48.

5.4.4 *Correlations between environmental measures*

A repeated measures correlation between the 50m GIS food outlet count and the self-reported food outlet count was significant but weak (*r*=0.17; *p*<.001), indicating that assessments of the food environment derived through GIS are similar to the self-reported environmental measure. As the local councils had slightly different classifications of food outlets, the study was unable to compare the self-reported types of food outlets with a GIS-derived assessment.

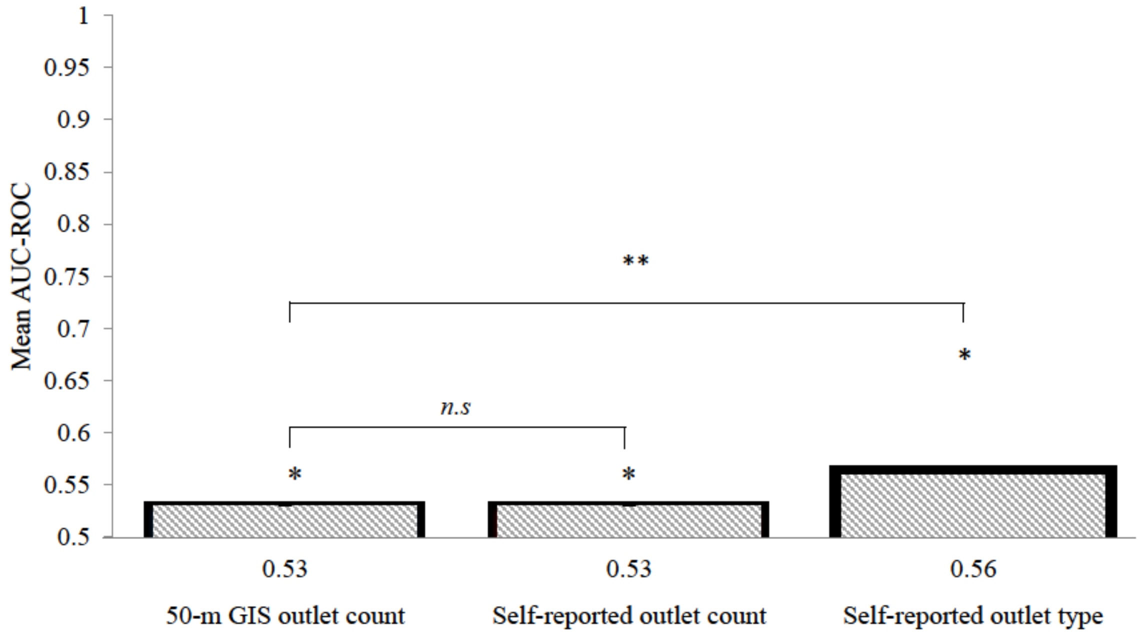


Figure 5.3 Mean area under the curve for the receiver operating characteristic curve (AUC-ROC) for each measure of the local food environment.

The AUC-ROC value represents the probability of accurately differentiating between eating and noneating instances. The * symbol denotes t tests, where the mean AUC-ROC was significantly different from 0.50. The ** symbol denotes t test where the AUC-ROC values were significantly different (at P<.02 threshold). n.s denotes models where the AUC-ROC values are not significantly different. Error bars indicate the *SE* for each model.

5.5 Discussion

5.5.1 *Principal findings*

This study used EMA methods to compare the assessments of momentary food environment using subjective and location stamp (GPS and GIS) data. The study found that the GIS-derived counts and self-reported counts of food outlets performed worse than the self-reported type of food outlets at predicting eating. These results suggest that subjective assessments of food outlet type are better predictors of momentary food intake and that the objective and subjective counts of food outlets may capture conceptually different aspects of the food environment compared with the subjective outlet type.

The finding that the type of food outlet nearby influences eating is consistent with findings from previous literature (Lucan & Mitra, 2012; Sanchez-Flack et al., 2018) and is likely to be evidence that food outlet density is a proxy measure for the availability of food. For example, living within one mile of a grocery store has been associated with increased fruit and vegetable intake (Zenk et al., 2009) and having numerous supermarkets in one's neighbourhood is associated with lower BMI (Morland et al., 2006). However, other types of food outlets are associated with increased unhealthy eating. For example, greater access to fast-food restaurants has been associated with a higher likelihood of fast-food purchasing (He et al., 2012) and a higher risk of overweight and obesity (Fuzhong et al., 2009; Morland et al., 2006; Kestens et al., 2012). Overall, this suggests that the type of food outlet in the environment influences individuals' diet and weight. Importantly, however, much of this previous research has relied on static assessments of individuals' environments, that is, their residential addresses. This research, however, examined momentary environments, thereby accounting for the fluctuations in the environments to which individuals are exposed to throughout the day, each day.

The finding that subjectively reported food outlet counts and objectively reported food outlet counts are equally predictive of behavioural indicators (i.e., eating) is novel. In the domain of physical activity, research has examined static environments and found inconsistencies between the availability and accessibility of parks to an individual and engagement in park-based physical activity (Cerin et al., 2018; Zhang et al., 2018). Assessing park proximity and acceptability (i.e., transport to parks, park paths or trails, and park cleanliness) differ based on whether the assessments are subjectively or objectively reported (Zhang et al., 2018). Given that the assessments of the environment are differentially associated with park-based physical activity based on the measurement type, it is possible that objectively and subjectively reported information may be tapping into conceptually different exposures. In terms of the momentary food environment as examined in this research, triggers to the craving and subsequent food intake may depend on the type of food outlet in an individual's immediate environment; such information is not captured through counts of nearby food outlets. Certain food outlets (e.g., fast food restaurants) may be more likely to trigger cravings than other food outlets (e.g., supermarkets) as the sights and smells from these outlets are associated with highly palatable food (Ferriday & Brunstrom, 2011). Therefore, subjectively reported food outlets— specifically, the type of food outlets nearby— may be better predictors of eating than count-based assessments of the food environment.

Despite finding a small correlation between the self-reported food outlet count and the 50m GIS count, there is minimal difference between subjective and objective measures of the number of food outlets within the environment. Overall, the results of this study suggest that the type of food outlet nearby is a better predictor of eating (vs noneating) than the density or number of food outlets. The difficulty with this is that there is a lack of standardization with the classification of food outlets. For example, an outlet can be classified as a butcher shop in one council and as a meat premise in another. For this reason, the study was unable to calculate GIS-based assessments of food outlet types. Therefore, passively collected data with subjective assessments of various food outlet types on eating could not be compared. Importantly, neither the objective nor the subject measure can be considered a truly *accurate* measure of food outlet density; both measures involve a degree of measurement error. As such, although it can be concluded that the 2 measures are aligned, the differences between the measures as evidence for over- or under-reporting of the subjective values cannot be used.

If the information on the food outlet types were measured consistently across councils, mHealth apps may be able to passively monitor an individual's location and proactively issue interventions before dietary lapses occurred. This could be useful given this study's finding that subjectively reported food outlet type is a better predictor of momentary food intake than either of the count-based measures. Alternatively, mHealth apps may be able to create personalized GIS maps of environmental triggers to eating by relying, at least initially, on subjective user input. Users could report their eating locations, and the corresponding GPS reports could be used to determine the locations where the users are most likely to consume unhealthy foods. When locations are repeatedly associated with unhealthy food intake, mHealth apps could then deliver just-in-time adaptive interventions to users.

The presence of restaurants, in particular, maybe a target for mHealth dietary apps using geofencing techniques. The energy content from meals consumed at restaurants has been found to contribute to most daily energy requirements (Roberts et al., 2018); thus, the presence of restaurants may be an appropriate target to reduce daily energy intake. Furthermore, some individuals may be particularly susceptible to eating unhealthy foods only when out (Spanakis et al., 2017). Although this study did not examine the within-person differences in the healthiness or energy intake derived from food intake when out, it was able to examine how eating can be prompted by cues in the immediate environment. Future studies should examine person-specific traits that increase vulnerability to unhealthy eating when out.

Overall, the findings of this study suggest that an individual's eating can be predicted based on his or her momentary environment. Although the self-reported type of food outlet nearby was the superior model in predicting eating, it only differentiated instances of eating vs noneating 56% of the time. It is possible that geofencing-based information may not be the best way to predict eating. However, research has demonstrated a relationship between the immediate food environment and individuals' food intake; therefore, the examination of whether subjectively reported environmental information is comparable to GIS-derived data provides a starting point toward creating simple user-friendly mHealth dietary interventions.

Although using GIS data for mHealth dietary interventions passively collects data and is, therefore, less burdensome for users, it is particularly time-consuming to code, placing the burden instead on the app developers. However, once GIS data have been coded, the process of data collection becomes automated, whereas subjectively reported information will continue to require manual intervention from the user. In addition, GIS maps can be calculated once and rolled out across multiple studies and numerous sites. Such wide-scale use of location information is easier with automated GIS data than subjectively reported data. Nevertheless, the costs and benefits of each method must be balanced between users and app developers.

The finding that the overall predictive ability of the presence of food outlets on predicting eating was modest is consistent with the idiosyncratic nature of how cues come to be associated with behaviours. For example, eating could be highly related to a particular cue for one person, but different cues will be important for other people. On the basis of these findings, for relevant individuals, it may be beneficial to issue personalized dietary interventions when they enter environments where they are most at risk of overeating or unplanned eating. Indeed, similar geofenced interventions have been successfully trialed in the literature for smoking (e.g., the Q-Sense app: Naughton et al., 2016). Q-Sense delivered support to users based on a 100m geofence from a location where the user reported smoking on at least 4 occasions (Naughton et al., 2016). It appears that mHealth apps may need to rely (at least initially) on user input to create relevant geofenced risk areas and, subsequently, generate place-based interventions. Importantly, research to date demonstrates that environmental interventions are feasible, and users report no privacy concerns with location-based data monitoring (Naughton et al., 2016).

5.5.2 *Strengths, limitations and future research*

This study has several strengths. To the researchers' knowledge, this study is the first to integrate 2 ways of assessing the effect of an individual's immediate food environment on his or her food choices. By using both objective measurements of the environment and subjective reports, we were able to compare how momentary environmental exposures influence real-time eating decisions. Such information provides a greater understanding of how individuals' dietary choices may be influenced by momentary environmental cues.

The use of EMA to assess eating and food environment enabled the examination of real-time environmental exposures and how they influence eating decisions. Previous studies (Jiao et al., 2015; Thornton et al., 2017) have highlighted the need to use spatial data to examine environmental exposures and develop precise estimates of where individuals travel and purchase foods. The use of GIS data in this study allowed for a better understanding of how fluctuations in the momentary food environment shape an individual's food choices. Furthermore, repeatedly assessing an individual's environmental exposures allows for in-depth information on the environmental antecedents and consequences of overeating and dietary lapses.

The use of real-time reporting of food intake means that the participants in this study reported their current situation, activities, and environmental exposures and were, therefore, less prone to biases associated with recall (Shiffman et al., 2008). Once behaviours are examined in real-time, an effective way of managing health-risk behaviours may be through issuing just-in-time adaptive interventions (Nahum-Shani et al., 2018). Just-in-time adaptive inventions may be able to utilize real-time cues, such as GPS-based information to identify individuals entering high-risk situations that require intervention and behavioural support (e.g., the A-CHESS app: Gustafson et al., 2014). The real-time aspect of this study is, therefore, the first step in identifying ways to conceptualize the environment to inform just-in-time adaptive interventions and mHealth apps.

Despite these strengths, there are some methodological limitations to this study. First, calculating GIS counts of food outlets from local council areas is difficult, and the GIS data are not sufficiently detailed to illustrate what types of food outlets exist. Furthermore, the local councils included in this study had different classification systems for recording food outlets, which meant that comparison among various council districts was feasible only by looking at the summary rather than the type of food outlets. Ideally, the best way to geocode food outlets would be to use a combination of council data, Google maps data, and by visiting neighbourhoods of interest to identify the type of food outlets present. Despite this being the ideal way to assess food outlets within the local environment, it would be extremely time-consuming and perhaps impractical in large cities with numerous food outlets. Future studies should explore different ways to classify the food environment so that the best and simplest measures are identified.

Second, by relying on food outlet counts (either GIS-derived or self-reported), the understanding regarding exactly what aspects of food outlets influence food choice was limited. Furthermore, this study did not separately examine the effect of each type of food outlet. Food choice is likely to be shaped by factors that are independent of food outlets, such as individual taste preferences and social norms (Lytle & Sokol, 2017), as well as the availability and affordability of foods (Jeffery et al., 2006), none of which are captured by assessing the counts of nearby food outlets. Further investigation into the availability and other choice determinants associated with food selection are warranted to investigate the aspects of food outlets that influence food choice.

Third, by focusing on GIS counts of food outlets, this study was unable to determine the food outlets and food-related cues that the individuals could see. There may have been times when the food outlets were in close proximity to the participants but were hidden from view. For example, there may be food outlets between buildings or hidden within lanes or buildings. As individuals' decisions relating to food choice are thought to be shaped by momentary exposures to food cues (Bailey, 2017), in situations where individuals cannot see nearby food outlets, they are unlikely to be influenced by their presence. Future research should consider other environmental exposures, such as advertising and food smells, in addition to the presence of food outlets in prompting individuals' food choices.

Fourth, as noted earlier, this study chose 50m as the radius as it was a rough approximation of the line of sight typical for urban settings. What someone can see from their current position will vary from place to place; this would have introduced error into this measure. Further work is required to determine the *optimal* unit of measurement; furthermore, it may prove fruitful to vary this measure from location to location based on the characteristics of the site.

Finally, the food outlet data from the local councils may not have been up-to-date. It is possible that there may have been a discrepancy between the GIS-derived food outlet count and the food outlets that were around and open during the time the study was conducted. Encapsulating the most recent and accurate information on the presence of food outlets is necessary to examine the association between the presence of food outlets and eating. Furthermore, this study did not consider the availability of food within each outlet. Factors like product availability and opening hours are likely to influence individuals' food options and, subsequently, their eating decisions. mHealth apps that require user input on environmental eating triggers will likely circumvent this issue. At present, mHealth interventions are unable to achieve targeted place–based information with passively collected data.

5.6 Conclusion

Examining the food outlets within one's environment is an important step in understanding how the built environment influences eating. This study found that although passively knowing an individual's environment can predict eating, knowing what type of food outlets are nearby is the best way for mHealth apps to create geofenced dietary interventions. Future advances in technology may enable passive calculation of the type of food outlets within a given geographical region. Such information would be integral to the success of geofenced interventions in mHealth dietary apps. In the meantime, mHealth apps will likely need to continue relying on users' self-reported information about their food environment to generate tailored geofenced dietary interventions.

Chapter 6 Discussion[13, 14]

[13] The protocol for the MunchIO app (mentioned in Section 6.3.1) is included in Appendix 6.1

[14] The publication for the stimulus control and eating study (mentioned in Section 6.3.1) is included in Appendix 6.2. Reference: Franja, S., Elliston, K. G., & Ferguson, S. G. (2020). Body Mass Index and stimulus control: Results from a real-world study of eating behaviour. *Appetite, 154*, 104783. https://doi.org/10.1016/j.appet.2020.104783

The overall aim of the present thesis was to investigate the individual and contextual determinants underlying discretionary food intake. Using an Ecological Momentary Assessment design (EMA: Shiffman, 2009), this thesis has explored stable motivational, and context-dependent, momentary cues prompting the consumption of discretionary foods. Four complimentary studies were conducted to address the overall thesis aim. The key aims, findings and conclusions from each of these studies are summarised in Sections 6.1.1 and 6.1.2 (see also Table 6.1). Briefly, Study 1 examined the role of inter-goal conflict and facilitation on daily dietary intake and long-term weight-loss. Study 2 applied Temporal Self-Regulation Theory (TST: Hall & Fong, 2007) to understand the relative importance of motivational versus momentary cues guiding food intake. Study 3 integrated stimulus control and food environment perspectives to examine the influence of both situational cues and the food environment on eating behaviour. Finally, Study 4 investigated whether objectively collected GPS location information could be used to predict snacking beyond subjectively reported measures of the immediate environment.

Together, these studies provide a comprehensive insight into how individual-level motivations and momentary factors within the immediate environment prompt real-time eating decisions. This Chapter integrates the findings from each of these four studies, highlighting both the theoretical and practical implications uncovered by this research, identifies areas for future research, discusses potential limitations and draws overall conclusions.

Table 6.1 Summary of the findings from each study presented in this thesis

	Aim(s)	Findings	Conclusions
Study 1, Chapter 2			
Elliston, K. G., Schüz B. & Ferguson, S. G. (2019). Inter-goal conflict and facilitation as predictors of adherence to dieting goals: An ecological momentary assessment study. *Psychology & Health, 35*(6): doi: 10.1080/08870446.2019.1684496	To examine the effect of perceived inter-goal facilitation and conflict on dietary intake and long-term weight loss.	Experiencing inter-goal conflict had a small impact on participants' mood, but this was not associated with changes in dietary intake or long-term weight-loss. Experiencing inter-goal facilitation was not associated with changes in daily dietary intake, nor was it a significant predictor of long-term weight-loss. However, overall daily food intake predicted weight-loss.	Given that participants lost weight between baseline and follow-up, they reached their weight loss goals. However, it is possible these goals were reached via means other than goal facilitation. The results suggest that inter-goal conflict/facilitation may not be relevant in the context of dieting.

Study 2, Chapter 3			
Elliston, K. G., Ferguson, S. G. & Schüz, B. (2017). Personal and situational predictors of everyday snacking: An application of temporal self-regulation theory. *British Journal of Health Psychology*. doi:10.1111/bjhp.12259	To examine how TST can be applied to understand the determinants of discretionary food choices.	Momentary cues to snacking (e.g., seeing others eat, experiencing negative affect and having snacks available) were important determinants of snacking, whereas person-level motivational predictors (e.g., behaviour intention, behavioural pre-potency and self-regulatory capacity) were less important than the momentary environment in prompting snacking.	Discretionary food intake is largely prompted by momentary cues. Motivational factors, such as intentions and self-regulation, are less important in the initiation of discretionary food intake.
Study 3, Chapter 4			
Elliston, K. G., Ferguson, S. G., Schüz, N. & Schüz, B. (2016).	To investigate the stimulus control and food environment	Internal cues (e.g., affect) and external cues (e.g., food	Perceptions of the momentary food environment influence food

Situational cues and momentary food environment predict everyday eating behavior in adults with overweight and obesity. *Health Psychology*. doi:10.1037/hea0000439	perspectives and examine the influence of both cues and the momentary food environment on food choice among adults with overweight and obesity.	availability, social situation, observing others eat) were associated with increased likelihood of eating. Additionally, the momentary food environment (e.g., the presence of food outlets) were associated with changes in snacking and/or main meal consumption depending on the type of outlet nearby.	choice- even when considered simultaneously with known situational and individual cues to eating such as social situation or affect.
Study 4, Chapter 5			
Elliston, K. G., Schüz, B., Albion, T. & Ferguson, S. G. (2020). Comparison of Geographic Information System and subjective assessments of	To investigate whether objectively collected location information predict snacking as effectively as subjectively reported environmental cues.	Although the GIS counts significantly predict eating, they were similar to self-reported food outlet counts. All food outlet counts performed worse than self-	Passively knowing an individual's environment can predict eating. However, knowing what type of food outlets are nearby is the best

momentary food environments as predictors of food intake: An Ecological Momentary Assessment Study. *JMIR mHealth uHealth, 8*(7): e15948. doi: 10.2196/15948		reported type of food outlets nearby.	way for mHealth apps to create geofenced dietary interventions.

6.1 Summary of findings

As outlined in Chapter 1, theories on eating have focused on two main aspects underlying food choice; more stable motivational and situation-specific, momentary predictors. Both aspects offer complementary perspectives on the determinants of food intake, however, research has traditionally examined them in isolation. Studies 1-4 of this thesis examine aspects of motivational and momentary cues associated with discretionary food intake. Sections 6.1.1 and 6.1.2 below outline key findings from Studies 1-4, and how they relate to motivational and momentary aspects of eating.

6.1.1 Motivational determinants underlying discretionary food intake

The motivational determinants underlying daily food choices were explored in Studies 1 and 2. Overall, the results from these studies suggest that motivational predictors play only a minimal role in guiding individuals' discretionary food choices. In Study 1, goal management was explored among individuals who were specifically focused on changing their eating behaviour. Despite having the intention to change behaviour, the results demonstrated that experiencing inter-goal conflict and facilitation were not related to daily dietary intake. It is possible that there are no effects of goal management on behaviour. However, this seems to contradict the link between intention and behaviour outlined in theoretical models such as the TPB (as outlined in Chapter 1, Section 1.4.1). Given that the TPB emphasises the importance of intentions guiding goal-directed behaviour, having no effect on goal management on dieting behaviour was unexpected.

Nevertheless, participants in Study 1 who reported consuming fewer daily snacks/overall daily food intake reported greater weight loss at follow-up. However, neither the experience of inter-goal conflict, nor inter-goal facilitation were associated with changes in weight during follow-up. Given that participants' weight differed between the baseline and follow-up assessments, participants reached their dieting goal to some degree, but the resulting weight loss may have been reached via means other than inter-goal facilitation.

Overall, the results from Study 1 found neither inter-goal conflict nor facilitation were significant predictors of discretionary or overall daily food intake. This suggests that the experience of goal conflict itself is not enough to impact upon dieting behaviour among those who are focused on changing their eating patterns. Overall, the impact of inter-goal conflict and facilitation does not appear to be via overall snack or food consumption. It is possible that the design of Study 1 did not allow us to fully explore the role of goal management on behaviour. In particular, we did not assess how participants prioritised their goals. It is possible that only highly prioritised goals predict intentions and engagement in behaviour. As a result, Study 2 was designed to further explore the role of motivational influences to discretionary food intake.

In Study 2, we applied TST to examine both the stable, motivational and context-dependent momentary predictors of food intake. Momentary cues such as seeing others eat, experiencing negative affect and having snacks available were associated with an increased likelihood of snacking. Furthermore, some motivational predictors such as temporal contingency, predicted snacking; those who perceive the cost of healthy eating to occur before the eating event were more likely to consume snacks. Additionally, low levels of self-regulation were associated with increased high-energy snacking. Overall, the results of Study 2 suggest that eating behaviour may be less controlled by deliberate decisions than momentary predictors; momentary cues within one’s environment may pose overwhelming challenges to the self-regulation of goal-directed eating.

6.1.2 Momentary determinants underlying discretionary food intake

Studies 3 and 4 further explored momentary cues underlying discretionary food intake. These studies examined the influence of contextual cues such as experiencing negative affect, the presence and absence of others eating, and being in close proximity to food outlets.

In Study 3, the perspective was expanded to include features of the food environment in addition to internal and external eating cues. Experiencing negative affect and being in close proximity to food outlets was associated with high-energy snacking, whereas being alone was associated with low-energy snacking. Additionally, the likelihood of high-energy snacking increased if a fast-food outlet was close by, and the odds of a low-energy snack increased when a supermarket or specialty food shop was close by. This is in line with existing literature suggesting that healthier food environments are associated with healthier food intake (e.g., Glanz & Yaroch, 2004; Fuzhong et al., 2009; Thornton & Kavanagh, 2012).

Finally, Study 4 showed that subjective representations of the environment had explanatory value over and above geographical information. Following this, an implication for interventions is that mHealth technology may be able to generate dietary interventions at critical times based on an individual's geographical location (further discussed in Section 6.3.1 below).

As outlined in section 1.4.2, momentary predictors of discretionary food intake are amenable to substantial fluctuation throughout each day. Although the momentary predictors explored in this thesis are not comprehensive (further discussed in Section 6.4.2), the findings may be used to inform behaviour change interventions. Section 6.2 below discusses future research directions to examining momentary cues to eating, Section 6.3.1 outlines some practical implications to address momentary food-related cues.

6.2 Theoretical implications

This section outlines the key theoretical implications resulting from this thesis. The role of dietary intentions, self-regulation and affect on discretionary food intake are explored. Overall, the results from Studies 1-4 suggest the presence of momentary cues are of key importance for real time eating decisions.

Discretionary food intake may be a combination of both individuals' intentions (surrounding their eating goals) and how they weigh up the health costs/benefits of their food intake. As outlined in Study 2, temporally close consequences are typically given priority over more distal effects. Individuals seeking short-term gratification tend to be more impulsive and engage in health risk behaviours than individuals who are more motivated by longer-term benefits. This may help explain the intention-behaviour gap in healthy eating (Glanz et al., 1998). Indeed, Collins and Mullan (2011) found that intention is more predictive for immediate hedonic behaviours. Therefore, contextual cues may be more important in prompting discretionary food intake than long-term dietary goals.

In Study 2 we found lower levels of self-regulation were associated with an increased likelihood of high-energy snacking. It is possible that higher levels of self-control are associated with health protective behaviours. However, self-regulation can fluctuate over time according to the presence of situational factors (Hofmann et al., 2012) and thus has potentially time-varying influences on health behaviour. Indeed, the ability to think objectively about food (such as the affordability of healthy food) is difficult when faced with palatable discretionary foods and food-related cues (Hill et al., 2016). The studies presented in this thesis did not explore fluctuations in self-regulation. Previous research has suggested dietary lapses are most likely to occur when self-regulatory resources are diminished. For example, when self-control resources are needed elsewhere (Hofmann et al., 2007), such as when one is feeling tired in the evening, or at home when “forbidden” food (i.e., a food that one was trying to avoid) is available (Forman et al., 2017; McKee et al., 2014). Findings from this thesis and previous research suggest that contextual cues (e.g., having palatable food available) prompt discretionary food intake. These contextual cues prompting eating may be particularly relevant during times where self-regulatory resources are under stress.

Additionally, self-regulation may be under stress when individuals are experiencing negative affect, such as feeling stressed or overwhelmed. Indeed, Studies 1-3 found negative affect was consistently associated with an increased likelihood of high-energy snacking and indeed, snacking overall. This is in line with some previous research (e.g., O'Connor et al., 2008; Parker et al., 2006; Schüz, Schüz, et al., 2015) and speaks to the role of eating being used as an attempt to minimise negative affect (Conner et al., 1999; Oliver et al., 2000). Despite comfort eating being popularised as a coping strategy, the findings on how emotion influences eating remain mixed, with some finding an association between negative mood and food intake (e.g., Jeffers, Mason, & Benotsch, 2019), whilst others have found an association between positive affect and food intake (e.g., Boh, Jansen et al., 2016; Liao et al., 2018).

A recent study by Reichenberger et al. (2020) suggests that the relationship between stress and eating is dependent on an individual’s trait stress-eating score. As a group, restrained eaters (i.e., dieters) may be particularly susceptible to consuming discretionary foods when stressed (Zellner et al., 2006). However, it is possible that it is not the absolute value of negative affect that prompts eating; snacking may be more driven by fluctuating levels of affect. Future research should examine the antecedents and consequences of affect following an eating episode to disentangle affect-related cause and consequences of discretionary food intake. We have recently done this and found unhealthy snacking was preceded by worsening affect. However, it did not lead to affective improvements afterwards, which questions the ‘effectiveness’ of comfort eating (manuscript under review).

Alongside discretionary food intake, other food choices may be associated with changes in affect. Indeed, Wahl et al. (2017) found that dinner elicited comparable happiness to snacking, and that unhealthy foods were not associated with increased positive affect compared to healthy food items. Indeed, even individuals’ comfort foods do not improve mood beyond other foods, or even no food (Wagner et al., 2014). According to Macht’s (2008) five-way model, food induced emotions control food intake, but intense emotions can suppress eating and, overall, the relationship between eating and mood depends on an individual’s motivation to eat. Despite the mixed results regarding affect and eating, findings from this thesis suggest momentary cues such as negative affect are associated with increased discretionary food intake. The populations most vulnerable to the influence of their emotions driving is unclear. Further research is therefore needed to both explore the role of affect and eating, and what groups would be most beneficial for dietary interventions to target.

6.3 Practical implications and future research directions

Examining within-person cues driving eating is the first step in being able to develop evidence-based and personalised dietary interventions. Section 6.3.1 below describes how to target and deliver health messages to individuals. Section 6.3.4 expands on this and identifies targets for change from a public health perspective, such as how the environmental structure and food availability influence food choice, and how food-related advertisements may also prompt discretionary food intake.

6.3.1 Targeting individual-level eating cues

Exploring the individual and contextual cues shaping eating is an important first step in understanding the determinants of eating behaviour, such information may then be used to inform behavioural interventions. Given that the results of Studies 1-4 demonstrate motivational factors tend to be less important in instances of momentary eating, interventions may need to do more than simply increase an individual's intentions towards healthy eating. Recent research has suggested that state (or momentary), motivations may be as important in shaping eating decisions than trait-level motivations (Wahl et al., 2020).

Current initiatives by the Australian Government such as Eat for Health (Australian Government, 2015) and the Healthy Weight Guide (Australian Government, 2014), aim to increase knowledge providing education on healthy eating and guidelines for maintaining a healthy weight. These initiatives would likely benefit by considering how momentary cues such as those outlined in Figure 6.1, can override an individual's intention to eat healthier.

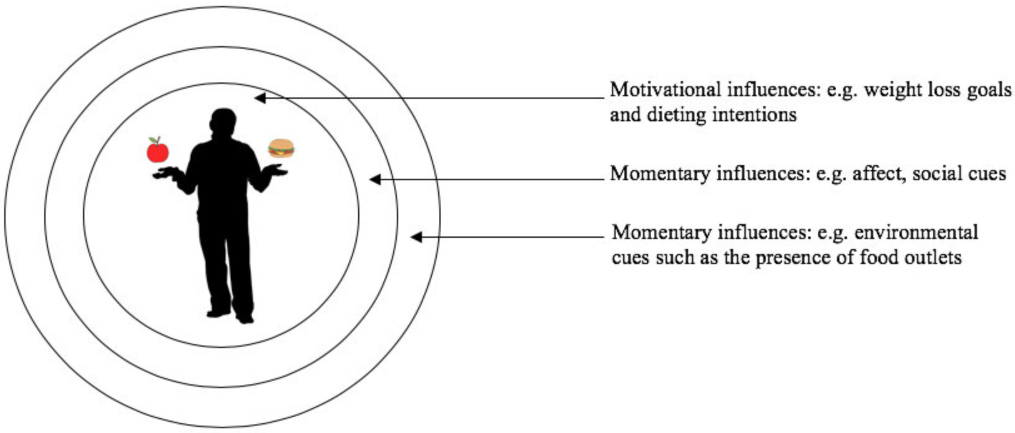


Figure 6.1 Diagram outlining what individual-level health interventions could target

Reminding individuals of their dietary goals through– for example– implementation intentions (Gollwitzer, 1999), may help strengthen their goals and override momentary cues prompting eating. Implementation intentions follow the structure "If I am stressed (cue exposure) then I will go for a walk (intention to avoid cue)". Implementation intentions link specific contexts/exposures with behavioural goals (Gollwitzer, 1999), enabling individuals to link situations and environments from their everyday life with their personal goals. In doing so, this may enable individuals to be reminded of their healthy eating goals as they move through their daily lives.

The nature of momentary factors which have been shown to prompt eating (e.g., having food available, being around others, experiencing negative affect), means that the contexts and situations an individual is exposed to fluctuate throughout the day. In order to account for the fluctuating presence/absence of cues, dietary interventions would benefit from targeting the momentary cues underlying an individual's discretionary food intake. Such interventions have been used in smoking cessation studies (e.g., Q-Sense; Naughton et al., 2016). Q-Sense is a mHealth app which identifies high-risk locations for smoking and creates geo-fenced cessation support; enabling real-time, personalised intervention support when it is most relevant to the individual (Naughton et al., 2016). However, such apps have not yet been applied in dietary interventions. Future dietary interventions could benefit from applying an mHealth framework to understand the idiosyncratic determinants of eating, and proactively feedback this information to individuals, thereby disrupting the cue-response mechanisms underlying discretionary food intake.

As outlined in Chapter 5, the immediate environment can be used to predict discretionary food intake. Therefore, certain environments can stimulate hunger and impulsive eating, specifically, being in close proximity to food outlets is associated with discretionary food intake (Elliston et al., 2020). There is some evidence to suggest there are weight-related differences in individuals' environmental exposures (e.g., Burgoine et al., 2017; Franja et al., 2020: included in Appendix 6.2). Dietary interventions may have greater success if they were both tailored to the individual and take environmental influences on eating into consideration. It may be possible for future mHealth interventions to automate this process, but as stated in Section 5.6, for now, we have to rely on self-reported exposures to food cues.

In order to assess and intervene when individuals are exposed to food cues, we designed an mHealth dietary app (called MunchIO: See Appendix 6.1 for the study protocol). The aim of MunchIO is to use idiosyncratic cues to issue personalised dietary support when individuals are most likely to consume discretionary foods. Similar to the EMA studies presented in this thesis, participants would record their snack intake and respond to randomly-timed assessments each day. The app would use this information to identify users' top three cue exposures that are associated with their discretionary food intake. The cue exposures would prompt users to generate implementation intentions to develop plans to maintain a healthy diet focusing on reducing discretionary food consumption.

MunchIO, and similar dietary apps could be a way for future dietary interventions to target individual-level health messages. As discussed in Section 1.7.2, mHealth apps create cost effective, accessible behaviour change interventions, with the potential to personalise content to the individual user. Furthermore, mHealth technology could allow for a more fine-grained understanding of the triggers underlying discretionary food intake across a variety of individuals. mHealth technology could be integrated with BCTs to allow for personalised, evidence-based, real-time interventions.

6.3.2 Targeting food cues within the home

The home environment may be a potential target for dietary interventions (see Section 1.5.5 for an outline of Glanz et al.'s 2005 model of the nutrition environment). Previous research has found that the homes of individuals with obesity tend to have more cues for eating. For example, they tend to have a greater variety and visibility of unhealthy foods, than households with individuals who have lower BMIs (Emery et al., 2015; Gorin et al., 2011). Findings from this thesis suggest that having discretionary food available and accessible serves as a cue for its consumption. In terms of promoting healthy dietary intake, reducing the availability of unhealthy food whilst simultaneously increasing the number of healthy products encourages individuals to consume more fruit and vegetables (Trapp et al., 2015).

Reducing food-related cues in the home begins when individuals shop for groceries. Making healthier food purchases at the supermarket enables individuals to control the availability– and therefore food-related cues– in their home environment (Trapp et al., 2015). Offering discounts, placing fruit and vegetable at the end of checkout aisles, and training supermarket staff to suggestively sell such products, has been found to increase fruit and vegetable purchases (e.g., Payne & Niculescu, 2018; Polascek et al., 2018). Such techniques may be a way to get more healthy food options into individuals' homes.

Further, changes within the home environment itself can be used to nudge individuals towards healthier food choices. Controlling exposures to food-related cues by restructuring the environment is an aspect of behavioural therapy (for an overview of behavioural approaches to the treatment of obesity see Wing, 2004). Health campaigns could promote these strategies to the public (see Section 6.3.4 below, for an overview of implications for future public health initiatives). For example, providing education on how to prepare simple, low-calorie foods, and to place them in prominent positions within one’s home such as the refrigerator and kitchen bench. Increasing the availability of healthy foods options within one’s home is one way of using environmental eating cues to nudge people towards healthier food choices.

6.3.3 Targeting urban design

Features of the built environment such as the availability of food outlets, are associated with changes in food intake (outlined in Glanz et al.’s 2005 model; Section 1.5.4). Environments where there is a high density of fast food outlets have higher rates of fast food consumption than environments with supermarkets and other healthy food alternatives (Inagami et al., 2009; Fuzhong et al., 2008; Turbutt et al., 2018). Living near a grocery store is associated with more daily servings of fruit and vegetables compared to individuals who do not live near a grocery store (Zenk et al., 2009). Such patterns were also found in the current thesis: Studies 3 and 4 demonstrated that the environment influences eating. In these studies, being in close proximity to food outlets was associated with a higher likelihood of discretionary food intake. Therefore, urban planners should consider how the nutrition environment shapes individual-level behaviours.

Given the association between the food environment and eating patterns, restricting the number of fast food outlets may help improve population health, particularly among those with greater area-level disadvantage. A potential avenue for urban planning to reduce obesity is being considered in the United Kingdom, where there are discussions around restricting fast food outlets to not open within 400m of schools (see Smith et al., 2013, for a review of the local food environment around schools and adolescent diet). This may be a way to reduce environmental exposure to food-related cues among vulnerable youth populations and subsequently reduce discretionary food intake.

Another way to alter the environment to reduce discretionary food consumption is to reduce the availability of energy-dense foods in populated areas. For example, removing vending machines around shopping centres and workplaces would reduce some of the environmental temptations nudging individuals towards discretionary food intake. Additionally, increasing access to healthy foods renders healthy foods a more automatic option, therefore decreasing the need to rely on an individual's self-regulatory ability to refrain from unhealthy food consumption (Frye & Shapiro, 2020).

6.3.4 Targeting public health messages

The goal of public health announcements is to inform the public on risk, and educate individuals on how to change their behaviour to mitigate risk. Public health campaigns targeting eating communicate the benefits of a healthy diet (e.g., the Eat for Health campaign: Australian Government, 2015), and highlight simple ways to change eating behaviour (e.g., the 'Swap it don't stop it' campaign; https://www.youtube.com/watch?v=AFWM97GelPc, or the 'Try for 5' campaign: (Nutrition Australia, 2016). Although informing individuals on risk is a step towards motivating people to change, providing information alone insufficient to change behaviour. Indeed, O'Hara et al.'s (2016) review on Australian mass media healthy eating campaigns suggests that creating awareness of lifestyle-related health behaviours is not sufficient to nudge behaviour change. Findings from this thesis suggest that individuals' intentions have minimal impact on real-time behavioural decisions such as food intake. Future research on public health interventions may wish to explore the societal influences surrounding eating, including food-related advertisements in the nutrition environment (see Figure 6.2).

As outlined by Glanz et al.'s (2005) model of the nutrition environment, food-related advertisements impact on individuals' health behaviours (see Section 1.5.6 for an overview of the consumer nutrition environment and eating). Food-related advertisements are ubiquitous; they appear on television, at sporting games and on public transport. Such saturation and large-scale exposure to discretionary foods can undermine an individual’s deliberate decision making towards healthier food options (Cohen & Babey, 2012). Television food-related advertisements are particularly successful in capturing individuals’ attention and increase their motivation to eat (Kemps et al., 2014). A reduction in food-related advertisements in the community would contribute towards decreasing individuals’ exposure to food-related cues, and may result in a reduction in discretionary food intake. Future research should further explore the role of food-related advertising as a possible target for public health interventions.

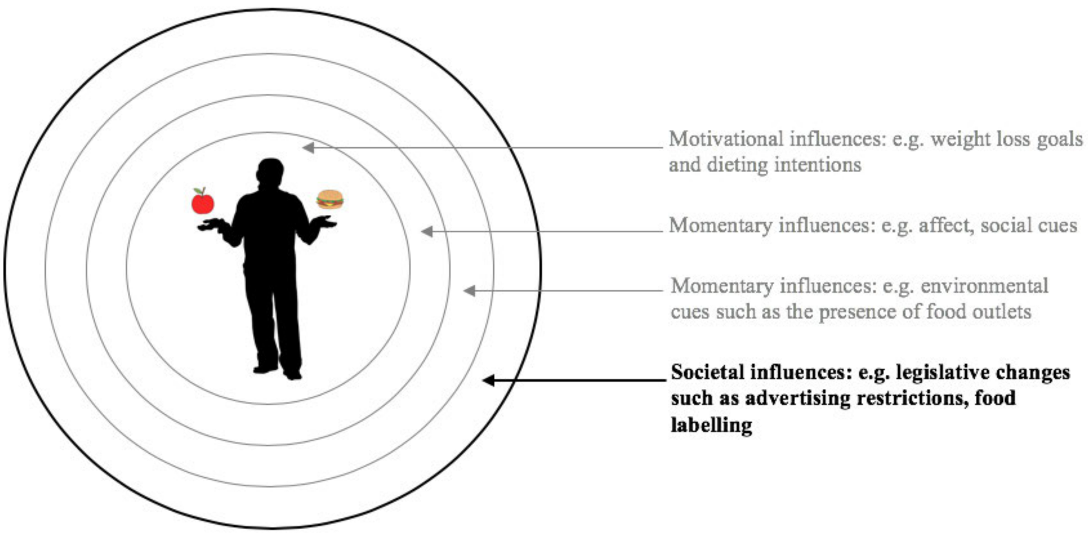


Figure 6.2 Diagram outlining the levels of influence underlying discretionary food intake that could be targets of future public health campaigns.

6.4 Strengths and limitations

6.4.1 Strengths

The studies in this thesis examined both the motivational and momentary determinants of discretionary food intake. This meant that we were able to examine how motivational influences such as an individual's goals and intentions, interact with and can be overridden by momentary cues such as affect level and social and environmental cues such as seeing others eat, and being in close proximity to food outlets. Such examination was a unique approach to understanding the individual and contextual determinants of discretionary food intake and establishes the need for future dietary interventions to address momentary eating cues.

A range of populations were examined throughout this thesis. For example, Study 1 examined individuals who are specifically trying to change their eating, Study 3 examined individuals with overweight and/or obesity, and Studies 2 and 4 examined individuals from across the BMI range. This allowed for a greater understanding of the determinants of snacking across key populations dietary interventions target. Furthermore, all studies included sample of individuals from the community, allowing for greater generalisability than previous dietary research, which has traditionally examined younger, mainly female participants (e.g., Kaisari & Higgs, 2015; Robinson et al., 2013).

All studies included in this thesis applied EMA methods to examine discretionary food intake. In doing so, we were able to examine individuals in their real environments over an extended period of time. This meant that we were able to overcome the key issue of ecological validity associated with laboratory research. As mentioned in Section 1.8.2, although the causal relationship between variables can be examined in laboratory settings, it is not always clear how this translates to real-world environments. By examining people in their usual environment, we were able to capture naturally occurring variations in individuals' experiences and examine how these change across a variety of contexts.

Through using both time and event-based sampling techniques, we were able to monitor different contextual factors (e.g., social and environmental factors), and internal states (e.g., individuals affect) in the days, hours or even minutes, leading up to discretionary food intake. We were then able to assess how such antecedents alter the probability of snacking. Such information is crucial to understanding how contextual determinants alter the likelihood of individuals consuming discretionary foods.

Participants in the studies included in this thesis reported on their current situation, activities and environmental exposures as they were making the decision to eat. Thereby facilitating more accurate reporting compared to having to recall such details retrospectively. Retrospectively recalling dietary intake is often highly inaccurate (e.g., Thomas et al., 2011). Asking individuals to report their dietary intake and contextual exposures in real-time was key to minimising recall biases and improving the accuracy of information reported.

Furthermore, we were able to examine the changes in food intake across days. Traditional data collection methods such as cross-sectional dietary surveys such as the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Healthy Diet Score (https://www.csiro.au/en/Research/Health/CSIRO-diets/Dietary-tools/CSIRO-Healthy-Diet-Score see Hendrie et al., 2016 for recent report on this measure), cannot capture fluctuations in food intake between days. However, previous research suggests that food intake changes across days of the week (Monteiro et al., 2017). For example, individuals tend to eat consume more energy, calories, and alcohol on weekends compared to during the week (Jahns et al., 2017). This may in part be explained by differences in activities during the weekend, such as increased socialisation compared to weekdays. Being able to control for day of week is therefore an important aspect for research on dieting to consider and it may impact the choice and implementation of dietary interventions.

By asking participants to record their dietary intake using specially-programmed electronic diaries, we were able to compare objective and subjective responses for their accuracy. For example, comparing GPS location with self-reported location information. We could also use compliance with the randomly-timed assessments to assess participants engagement in the study protocol (across the Studies, compliance with the randomly-timed assessments were high: Study mean ranged between 77.96 and 95.29%, indicating participants engaged with the study protocols well). The ability to verify responses with objective measurements and quantify participants engagement with the study protocols means that we can be more confident in the accuracy of the self-reported dietary information; a difficultly in other dietary studies using self-reported information.

6.4.2 Limitations

Despite the strengths of this research, there are methodological limitations of the studies presented in this thesis. As participants monitored their food intake and did not participate in an intervention, all associations between the determinants of eating and discretionary food intake were correlational. This means that we were unable to separate out whether participants were eating because of the presence of contextual cues within their environment, or if they were actively seeking out environments in order to then eat. However, the predictors of food intake in presented in this thesis are largely consistent with experimental research from laboratory studies (e.g., Higgs, 2015; McFerran et al., 2010), suggesting our interpretation of eating cues is accurate. Future studies could include a qualitative component so that individuals can explain the different ways they balance their dietary intentions with their desire for discretionary foods, especially when faced with environmental temptations.

Despite our multi-assessment approach to classify daily food intake, our assessment of discretionary items was limited. For example, we did not include alcohol or items such as fruit and nut bars, dried fruit and potato chips. Alcohol intake in particular, is likely to be influenced by contextual factors such as social norms (Chauvin, 2011) and proximity to alcohol and tobacco outlets (West et al., 2010), and has recently been found to be the greatest contributor to total discretionary intake, especially for older age groups (Hendrie et al., 2016). By omitting these items from our assessments of discretionary intake, we were able to reduce participant burden, but may have underestimated overall discretionary intake.

Future studies could use the Healthy Diet Score (based on the Australian dietary guidelines and developed by the CSIRO: https://www.csiro.au/en/Research/Health/CSIRO-diets/Dietary-tools/CSIRO-Healthy-Diet-Score) to classify the health of an individual's dietary intake compared to the Australian Dietary Guidelines. The assessment generates a score ranking diet quality from 0 to 100 (full compliance with the dietary guidelines). The diet scores can be used to compare diet quality both between individuals, and within an individual over time (e.g., in weight loss studies). Future dietary studies looking at diet quality over time may benefit from incorporating information from the Healthy Diet Score into the assessments of food intake.

Throughout the studies incorporated in this thesis, we did not assess the portion size of foods participants consumed. It is possible that for some food items (e.g., a home-made burger), one serving would not necessarily be considered unhealthy, but if eaten in excessive quantities, or in large portions, it may be. Future studies could use photographs of food images to evaluate portion size. Indeed, the use of photography to capture food intake is already underway (e.g., Christoph et al., 2017; Norman et al., 2020). Even with the use of photographs to estimate portion sizes, calculating portion sizes of EMA data is difficult. Researchers would need to examine the photographs of the whole sample (e.g., 60 participants) for each of their food reports (e.g., 3 meals and 2 snacks per day) over 14 days; resulting in over 4,000 images to assess; a difficult and time-consuming task. It is possible that future technological developments will allow for an easier way of assessing portion sizes.

Throughout Studies 1-4, participants reported their food intake via self-reported measures. It is possible that participants may not have accurately reported what they were eating. For example, they may have underreported discretionary food intake in an attempt to avoid judgement of their eating patterns (see Hebert et al., 1995 for a review of social desirability bias in dietary intake measures). However, compliance with the randomly-timed assessments was high, suggesting participants were engaged with the study protocol. Furthermore, reporting discretionary foods in real-time may be less confronting than asking individuals to recall and tally all instances of discretionary food intake from throughout the day, thereby reducing concerns related to social desirability biases in our studies.

By asking participants to report their food intake and presence of contextual cues, there is the possibility of increasing individuals' awareness to the cues in their environment than they would normally be conscious of. This reactivity is could induce discretionary food intake beyond individual's typical consumption levels. However, there is currently little evidence to suggest EMA methods induce reactivity (e.g., Hufford et al., 2002). Future research should continue to investigate the potential for reactivity in dietary-based EMA research.

It is possible there is a difference between eating decisions and eating behaviours. In Studies 1-4, we assessed individuals' decision to eat which we then interpreted as reflecting their food intake. It is possible that such post hoc assessments of eating decisions may not correspond with the cues which were present at the time of eating. Nevertheless, as we were interested in the presence of cues that prompt food intake, assessing the presence of cues at the time individuals decided to eat is an appropriate way to assess exposure to food-related cues. Future research should explore whether there are any differences in foods chosen between when individuals make the decision to eat and their subsequent eating behaviour.

Finally, the momentary-level factors explored in this thesis are not comprehensive. It is possible that key momentary cues and other contextual factors that may impact eating decisions were not assessed. For example, the relationship between affect and eating warrants further exploration (see Section 6.2 for an overview of the research exploring affect and eating). Additionally, exploring cues such as the role of food advertising on eating would allow for greater understanding of how attentional processes shape food intake. A more comprehensive assessment of momentary predictors of food intake would allow for further identification of targets for dietary interventions.

6.5 Conclusions

This thesis has used an EMA design across four complimentary studies to explore the individual and contextual determinants of discretionary food intake. Results from Studies 1-4 suggest discretionary food intake is largely prompted by contextual determinants such as experiencing negative affect, the presence of social cues, and environmental cues such as the availability of food and proximity to food outlets. Stable, individual-level determinants such as individuals' intention, behavioural pre-potency and self-regulation were less important in prompting momentary food intake.

Taken together, the findings from this thesis serve to identify potential interventions for dietary change. These include reminding individuals of their dietary goals through the use of implementation intentions to facilitate better adherence to dietary goals when facing temptations to eat. In terms of public health messages, education on healthy food choices alone may be insufficient to modify individuals' dietary intake. Both the home and built environments can be targets for change, through increasing the availability of healthy food options, reducing food-related advertisements, and placing restrictions on the number of new food outlets within vulnerable areas. A combination of these approaches may reduce the impact of discretionary food intake on both individual and population-level health outcomes.

References

Aarts, H. (2007). Health and goal-directed behavior: The nonconscious regulation and motivation of goals and their pursuit. *Health Psychology Review*, *1*(1), 53-82. https://doi.org/10.1080/17437190701485852

Aarts, H., & Dijksterhuis, A. (2000). Habits as knowledge structures: Automaticity in goal-directed behavior. *Journal of Personality and Social Psychology*, *78*(1), 53-63. https://doi.org/10.1037/0022-3514.78.1.53

Aarts, H., Verplanken, B., & Van Knippenberg, A. (1998). Predicting behavior from actions in the past: Repeated decision making or matter of habit? *Journal of Applied Social Psychology*, *28*(15), 1355-1374.

ABS. (2011). *1270.0.55.004- Australian Statistical Geography Standard (ASGS): Vol 4- Significant Urban Areas, Urban Centres and Localities, Section of State, July 2011*. Retrieved December 15, 2016 from http://www.abs.gov.au/ausstats/abs@.nsf/mf/1270.0.55.004

ABS. (2015, October 15). *Australian Health Survey: Nutrition first results- food and nutrients, 2011-12*. Retrieved October 14, 2016 from http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/4364.0.55.007~2011-12~Main%20Features~Dieting~500

ABS. (2017). *6530.0 Household expenditure survey, Australia: Summary of results, 2015-16*. Retrieved July 11, 2019 from https://www.abs.gov.au/ausstats/abs@.nsf/Latestproducts/6530.0Main%20Features102015-16?opendocument&tabname=Summary&prodno=6530.0&issue=2015-16&num=&view=

ABS. (2018). *4364.0.55.001—National health survey: first results, 2017- 18*. Retrieved April 17, 2019 from http://www.abs.gov.au/ausstats/abs@.nsf/mf/4364.0.55.001

Adriaanse, M. A., de Ridder, D. T., & de Wit, J. B. (2009). Finding the critical cue: implementation intentions to change one's diet work best when tailored to personally relevant reasons for unhealthy eating. *Personality and Social Psychology Bulletin*, *35*(1), 60-71. https://doi.org/10.1177/0146167208325612

Adriaanse, M. A., Gollwitzer, P. M., De Ridder, D. T., de Wit, J. B., & Kroese, F. M. (2011). Breaking habits with implementation intentions: A test of underlying processes. *Personality and Social Psychology Bulletin*, *37*(4), 502-513. https://doi.org/10.1177/0146167211399102

Adriaanse, M. A., Vinkers, C. D., De Ridder, D. T., Hox, J. J., & De Wit, J. B. (2011). Do implementation intentions help to eat a healthy diet? A systematic review and meta-analysis of the empirical evidence. *Appetite*, *56*(1), 183-193. https://doi.org/10.1016/j.appet.2010.10.012

AIHW. (2016a). *Body Weight*. Retrieved August 18, 2016 from http://www.aihw.gov.au/body-weight/

AIHW. (2016b). *Overweight and Obesity*. Retrieved October 14, 2016 from http://www.aihw.gov.au/overweight-and-obesity/

Ajzen, I. (1991). The Theory of Planned Behavior. *Organizational Behaviour and Human Decision Processes 50*, 179-211.

Allan, J. L., Johnston, M., & Campbell, N. (2010). Unintentional eating. What determines goal-incongruent chocolate consumption? *Appetite*, *54*(2), 422-425. https://doi.org/10.1016/j.appet.2010.01.009

Allom, V., Panetta, G., Mullan, B., & Hagger, M. S. (2016). Self-report and behavioural approaches to the measurement of self-control: Are we assessing the same construct? *Personality and Individual Differences*, *90*, 137-142. https://doi.org/10.1016/j.paid.2015.10.051

An, R. (2016). Fast-food and full-service restaurant consumption and daily energy and nutrient intakes in US adults. *European Journal of Clinical Nutrition*, *70*(1), 97-103. https://doi.org/10.1038/ejcn.2015.104

Annesi, J. J., & Mareno, N. (2014). Temporal aspects of psychosocial predictors of increased fruit and vegetable intake in adults with severe obesity: Mediation by physical activity. *Journal of Community Health*, *39*(3), 454-463. https://doi.org/10.1007/s10900-014-9828-8

Annesi, J. J., Mareno, N., & McEwen, K. L. (2016). Mediation of self-regulation and mood in the relationship of changes in high emotional eating and nutritional behaviors: Moderating effects of physical activity. *Scandinavian Journal of Psychology*, *57*(6), 523-534. https://doi.org/10.1111/sjop.12327

Antezana, G., Venning, A., Blake, V., Smith, D., Winsall, M., Orlowski, S., & Bidargaddi, N. (2018). An evaluation of behaviour change techniques in health and lifestyle mobile applications. *Health Informatics Journal*. https://doi.org/10.1177/1460458218813726

Apovian, C. M. (2016). The obesity epidemic: Understanding the disease and the treatment. *New England Journal of Medicine, 374*(2), 177-179. https://doi.org/10.1056/NEJMe1514957

Arem, H., & Irwin, M. (2011). A review of web-based weight loss interventions in adults. *Obesity Reviews*, *12*(5), e236-e243. https://doi.org/10.1111/j.1467-789X.2010.00787.x

Australian Government. (2014). *Healthy Weight Guide*. Retrieved May 29, 2019 from http://healthyweight.health.gov.au/wps/portal/Home/home/!ut/p/a1/04_Sj9CPykssy0xPLMnMz0vMAfGjzOI9jFxdDY1MDD3dzbycDTzNLfwsfP2AAsbGQAWRQAUGOICjASH94fpRYCXO7o4eJuY-

QD0mFkYGni5OHi7mlr4GBp5mUAV4rCjIjTDIdFRUBADr1DFv/dl5/d5/L2dBISEvZ0FBIS9nQSEh/

Australian Government. (2015). *Eat for health*. National Health and Medical Research Council. Retrieved May 29, 2019 from https://www.eatforhealth.gov.au/

Avenell, A., Brown, T., McGee, M., Campbell, M., Grant, A., Broom, J., Jung, R., & Smith, W. (2004). What interventions should we add to weight reducing diets in adults with obesity? A systematic review of randomized controlled trials of adding drug therapy, exercise, behaviour therapy or combinations of these interventions. *Journal of Human Nutrition and Dietetics*, *17*(4), 293-316. doi: 10.1111/j.1365-277X.2004.00530.x.

Bailey, R. L. (2017). Influencing eating choices: biological food cues in advertising and packaging alter trajectories of decision making and behavior. *Health Commun*, *32*(10), 1183-1191. https://doi.org/10.1080/10410236.2016.1214222

Bakdash, J. Z., & Marusich, L. R. (2017). Repeated Measures Correlation. *Frontiers in Psychology*, *8*. https://doi.org/10.3389/fpsyg.2017.00456

Ball, K., & Thornton, L. (2013). Food environments: Measuring, mapping, monitoring and modifying. *Public Health Nutrition*, *16*(7), 1147-1150. https://doi.org/10.1017/S1368980013001304

Baranowski, T., Cullen, K. W., Nicklas, T., Thompson, D., & Baranowski, J. (2003). Are current health behavioral change models helpful in guiding prevention of weight gain efforts? *Obesity Research*, *11 Suppl*, 23S-43S. https://doi.org/10.1038/oby.2003.222

Barclay, A. W., & Brand-Miller, J. (2011). The Australian paradox: A substantial decline in sugars intake over the same timeframe that overweight and obesity have increased. *Nutrients*, *3*(4), 491-504. https://doi.org/10.3390/nu3040491

Barnes, T. L., Bell, B. A., Freedman, D. A., Colabianchi, N., & Liese, A. D. (2015). Do people really know what food retailers exist in their neighborhood? Examining GIS-based and perceived presence of retail food outlets in an eight-county region of South Carolina. *Spatial Spatio-temporal Epidemiology*, *13*, 31-40. https://doi.org/10.1016/j.sste.2015.04.004

Barta, W. D., Tennen, H., & Litt, M. D. (2012). *Measurement reactivity in diary research.* In M. R. Mehl & T. S. Conner (Eds.), *Handbook of research methods for studying daily life* (p. 108–123). The Guilford Press.

Bates, D., Mächler, M., Bolker, B., & Walker, S. (2015). Fitting Linear Mixed-Effects Models Usinglme4. *Journal of Statistical Software, 67*(1). https://doi.org/10.18637/jss.v067.i01

Baumeister, R. F. (2002). Yielding to temptation: Self-control failure, impulsive purchasing, and consumer behavior. *Journal of Consumer Research*, *28*(4), 670-676. https://doi.org/Doi 10.1086/338209

Baumeister, R. F., & Vohs, K. D. (2007). Self-regulation, ego depeltion, and motivation. *Social and Personality Psychology Compass, 1*(1). 115-128. https://doi.org/10.1111/j.

Baumeister, R. F., Heatherson, T., & Tice, D. (1994). *Losing control: How and why people fail at self-regulation*. Academic Press Inc., San Diego, California.

Beckjord, E., & Shiffman, S. (2014). Background for real-time monitoring and intervention related to alcohol use. *Alcohol Research*, *36*(1), 9-18.

Beeken, R. J., Leurent, B., Vickerstaff, V., Wilson, R., Croker, H., Morris, S., Omar, R. Z., Nazareth, I., & Wardle, J. (2017). A brief intervention for weight control based on habit-formation theory delivered through primary care: Results from a randomised controlled trial. *International Journal of Obesity (London), 41*(2), 246-254. https://doi.org/10.1038/ijo.2016.206

Bellisle, F., & Dalix, A. M. (2001). Cognitive restraint can be offset by distraction, leading to increased meal intake in women. *American Journal of Clinical Nutrition*, *74*(2), 197-200. https://doi.org/10.1093/ajcn/74.2.197

Berg, K. C., Crosby, R. D., Cao, L., Crow, S. J., Engel, S. G., Wonderlich, S. A., & Peterson, C. B. (2015). Negative affect prior to and following overeating-only, loss of control eating-only, and binge eating episodes in obese adults. *International Journal of Eating Disorders*, *48*(6), 641-653. https://doi.org/10.1002/eat.22401

Berkman, E. T., Giuliani, N. R., & Pruitt, A. K. (2014). Comparison of text messaging and paper-and-pencil for ecological momentary assessment of food craving and intake. *Appetite*, *81*, 131-137. https://doi.org/10.1016/j.appet.2014.06.010

Berridge, K. C., Ho, C. Y., Richard, J. M., & DiFeliceantonio, A. G. (2010). The tempted brain eats: Pleasure and desire circuits in obesity and eating disorders. *Brain Research*, *1350*, 43-64. https://doi.org/10.1016/j.brainres.2010.04.003

Blackburn, H., & Jacobs, D., Jr. (2014). Commentary: Origins and evolution of body mass index (BMI): continuing saga. *International Journal of Epidemiology*, *43*(3), 665-669. https://doi.org/10.1093/ije/dyu061

Bodor, J. N., Rose, D., Farley, T. A., Swalm, C., & Scott, S. K. (2007). Neighbourhood fruit and vegetable availability and consumption: The role of small food stores in an urban environment. *Public Health Nutrition*, *11*(4), 413-420. https://doi.org/10.1017/S1368980007000493

Boh, B., Jansen, A., Clijsters, I., Nederkoorn, C., Lemmens, L. H., Spanakis, G., & Roefs, A. (2016). Indulgent thinking? Ecological Momentary Assessment of overweight and healthy-weight participants' cognitions and emotions. *Behaviour Research and Therapy*, *87*, 196-206. https://doi.org/10.1016/j.brat.2016.10.001

Boh, B., Lemmens, L. H., Jansen, A., Nederkoorn, C., Kerkhofs, V., Spanakis, G., Weiss, G., & Roefs, A. (2016). An Ecological Momentary Intervention for weight loss and healthy eating via smartphone and Internet: Study protocol for a randomised controlled trial. *Trials*, *17*, 154. https://doi.org/10.1186/s13063-016-1280-x

Bongers, P., Jansen, A., Houben, K., & Roefs, A. (2013). Happy eating: The single target implicit association test predicts overeating after positive emotions. *Eating Behaviors*, *14*(3), 348-355. https://doi.org/10.1016/j.eatbeh.2013.06.007

Booker, L., & Mullan, B. (2013). Using the Temporal Self-regulation Theory to examine the influence of environmental cues on maintaining a healthy lifestyle. *British Journal of Health Psychology*, *18*(4), 745-762. https://doi.org/10.1111/bjhp.12015

Boudreaux, M. J., & Ozer, D. J. (2012). Goal conflict, goal striving, and psychological well-being. *Motivation and Emotion*, *37*(3), 433-443. https://doi.org/10.1007/s11031-012-9333-2

Boyland, E. J., & Halford, J. C. (2013). Television advertising and branding. Effects on eating behaviour and food preferences in children. *Appetite*, *62*, 236-241. https://doi.org/10.1016/j.appet.2012.01.032

Bradley, A. P. (1997). The use of the area under the ROC curve in the evaluation of machine learning algorithms. *Pattern Recognition*, *30*(7), 1145-1159. https://doi.org/10.1016/S0031-3203(96)00142-2

Burgoine, T., Mackenbach, J. D., Lakerveld, J., Forouhi, N. G., Griffin, S. J., Brage, S., Wareham, N. J., & Monsivais, P. (2017). Interplay of socioeconomic status and supermarket distance is associated with excess obesity risk: A UK cross-sectional study. *International Journal of Environmental Research and Public Health*, *14*(11). https://doi.org/10.3390/ijerph14111290

Burgoine, T., & Monsivais, P. (2013). Characterising food environment exposure at home, work, and along community journeys using data on adults in the UK. *International Journal of Behavioral Nutrition and Physical Activity*, *10*(85), 2-11.

Burke, L. E., Shiffman, S., Music, E., Styn, M. A., Kriska, A., Smailagic, A., Siewiorek, D., Ewing, L. J., Chasens, E., French, B., Mancino, J., Mendez, D., Strollo, P., & Rathbun, S. L. (2017). Ecological Momentary Assessment in behavioral research: Addressing technological and human participant challenges. *Journal of Medical Internet Research*, *19*(3), e77. https://doi.org/10.2196/jmir.7138

Burke, L. E., Zheng, Y., Ma, Q., Mancino, J., Loar, I., Music, E., Styn, M., Ewing, L., French, B., Sieworek, D., Smailagic, A., & Sereika, S. M. (2017). The SMARTER pilot study: Testing feasibility of real-time feedback for dietary self-monitoring. *Preventive Medicine Reports*, *6*, 278-285. https://doi.org/10.1016/j.pmedr.2017.03.017

Businelle, M. S., Ma, P., Kendzor, D. E., Frank, S. G., Wetter, D. W., & Vidrine, D. J. (2016). Using intensive longitudinal data collected via mobile phone to detect imminent lapse in smokers undergoing a scheduled quit attempt. *Journal of Medical Internet Research*, *18*(10), e275. https://doi.org/10.2196/jmir.6307

Caballero, B. (2007). The global epidemic of obesity: An overview. *Epidemiologic Reviews*, *29*, 1-5. https://doi.org/10.1093/epirev/mxm012

Cameron, L. D. (2010). Temporal Self-Regulation Theory: Towards a more comprehensive understanding of health behaviour. *Health Psychology Review*, *4*(2), 70-74. https://doi.org/10.1080/17437191003681537

Campbell, K. L., Babiarz, A., Wang, Y., Tilton, N. A., Black, M. M., & Hager, E. R. (2018). Factors in the home environment associated with toddler diet: An

Ecological Momentary Assessment study. *Public Health Nutrition*, 1-10. https://doi.org/10.1017/S1368980018000186

Cannuscio, C. C., Tappe, K., Hillier, A., Buttenheim, A., Karpyn, A., & Glanz, K. (2013). Urban food environments and residents' shopping behaviors. *American Journal of Preventive Medicine*, *45*(5), 606-614. https://doi.org/10.1016/j.amepre.2013.06.021

Cappelleri, J. C., Bushmakin, A. G., Gerber, R. A., Leidy, N. K., Sexton, C. C., Karlsson, J., & Lowe, M. R. (2009). Evaluating the Power of Food Scale in obese subjects and a general sample of individuals: development and measurement properties. *International Journal of Obesity (2005)*, *33*(8), 913-922. https://doi.org/10.1038/ijo.2009.107

Carels, R., Hoffman, J., Collins, A., Raber, A., Cacciapaglia, H., & O'Brien, W. (2001). Ecological Momentary Assessment of temptation and lapse in dieting. *Eating Behaviors*, 307-321.

Cerin, E., Conway, T. L., Adams, M. A., Barnett, A., Cain, K. L., Owen, N., Christiansen, L. B., van Dyck, D., Mitas, J., Sarmiento, O. L., Davey, R. C., Reis, R., Salvo, D., Schofield, G., & Sallis, J. F. (2018). Objectively-assessed neighbourhood destination accessibility and physical activity in adults from 10 countries: An analysis of moderators and perceptions as mediators. *Social Science and Medicine*, *211*, 282-293. https://doi.org/10.1016/j.socscimed.2018.06.034

Chaix, B., Kestens, Y., Perchoux, C., Karusisi, N., Merlo, J., & Labadi, K. (2012). An interactive mapping tool to assess individual mobility patterns in neighborhood studies. *American Journal of Preventive Medicine*, *43*(4), 440-450. https://doi.org/10.1016/j.amepre.2012.06.026

Chandon, P., Hutchinson, J. W., Bradlow, E. T., & Young, S. H. (2009). Does in-store marketing work? Effects of the number and position of shelf facings on brand attention and evaluation at the point of purchase. *Journal of Marketing, 73*(6), 1-17.

Chapman, C. D., Benedict, C., Brooks, S. J., & Schioth, H. B. (2012). Lifestyle determinants of the drive to eat: A meta-analysis. *American Journal of Clinical Nutrition, 96*(3), 492-497. https://doi.org/10.3945/ajcn.112.039750

Chauvin, C. D. (2012). Social norms and motivations associated with college binge drinking*. *Sociological Inquiry, 82*(2), 257-281. https://doi.org/10.1111/j.1475-682X.2011.00400.x

Chen, J., Cade, J. E., & Allman-Farinelli, M. (2015). The most popular smartphone apps for weight loss: A quality assessment. *JMIR mHealth and uHealth*, *3*(4). https://doi.org/10.2196/mhealth.4334

Christoph, M. J., Loman, B. R., & Ellison, B. (2017). Developing a digital photography-based method for dietary analysis in self-serve dining settings. *Appetite*, *114*, 217-225. https://doi.org/10.1016/j.appet.2017.03.050

Cleo, G., Glasziou, P., Beller, E., Isenring, E., & Thomas, R. (2018). Habit-based interventions for weight loss maintenance in adults with overweight and obesity: a randomized controlled trial. *International Journal of Obesity (2005)*. https://doi.org/10.1038/s41366-018-0067-4

Cleobury, L., & Tapper, K. (2014). Reasons for eating 'unhealthy' snacks in overweight and obese males and females. *Journal of Human Nutrition and Dietetics*, *27*(4), 333-341. https://doi.org/10.1111/jhn.12169

Coelho, J. S., Jansen, A., Roefs, A., & Nederkoorn, C. (2009). Eating behavior in response to food-cue exposure: examining the cue-reactivity and counteractivecontrol models. *Psychology of Addictive Behaviors*, *23*(1), 131-139. https://doi.org/10.1037/a0013610

Cohen, D. A. (2008). Obesity and the built environment: Changes in environmental cues cause energy imbalances. *International Journal of Obesity, 32 Suppl 7,* S137-142. https://doi.org/10.1038/ijo.2008.250

Cohen, D. A., & Babey, S. H. (2012). Contextual influences on eating behaviours: Heuristic processing and dietary choices. *Obesity Reviews*, *13*(9), 766-779. https://doi.org/10.1111/j.1467-789X.2012.01001.x

Collins, A., & Mullan, B. (2011). An extension of the Theory of Planned Behavior to predict immediate hedonic behaviors and distal benefit behaviors. *Food Quality and Preference*, *22*(7), 638-646. https://doi.org/10.1016/j.foodqual.2011.03.011

Collins, C. E., Morgan, P. J., Jones, P., Fletcher, K., Martin, J., Aguiar, E. J., Lucas, A., Neve, M., McElduff, P., & Callister, R. (2010). Evaluation of a commercial web-based weight loss and weight loss maintenance program in overweight and obese adults: A randomized controlled trial. *BMC Public Health*, *10*(669). https://doi.org/Artn 66910.1186/1471-2458-10-669

Conner, M., Abraham, C., Prestwich, A., Hutter, R., Hallam, J., Sykes-Muskett, B., Morris, B., & Hurling, R. (2016). Impact of goal priority and goal conflict on the intention-health-behavior relationship: Tests on physical activity and other health behaviors. *Health Psychology*, *35*(9), 1017-1026. https://doi.org/10.1037/hea0000340

Conner, M., Fitter, M., & Fletcher, W. (1999). Stress and snacking: A diary study of daily hassles and between-meal snacking. *Psychology & Health*, *14*, 51-63.

Conner, T. S., & Lehman, B. (2012). Getting Started: Launching a study in daily life. In M. Mehl & T. S. Conner (Eds.), *Handbook of Research Methods for Studying Daily Life*. The Guilford Press, New York.

Cornell, C., Rodin, J., & Weingarten, H. (1988). Stimulus-Induced Eating When Satiated. *Psychology & Behavior*, *45*, 695-704.

Corr, P. J. (2013). Approach and avoidance behaviour: Multiple systems and their interactions. *Emotion Review*, *5*(3), 285-290. https://doi.org/10.1177/1754073913477507

Correa, T., Fierro, C., Reyes, M., Dillman Carpentier, F. R., Taillie, L. S., & Corvalan, C. (2019). "Responses to the Chilean law of food labeling and advertising: exploring knowledge, perceptions and behaviors of mothers of young children". *The International Journal of Behavioral Nutrition and Physical Activity*, *16*(1), 21. https://doi.org/10.1186/s12966-019-0781-x

Corstorphine, E., Waller, G., Ohanian, V., & Baker, M. (2006). Changes in internal states across the binge-vomit cycle in bulimia nervosa. *Journal of Nervous and Mental Disease*, *194*(6), 446-449. https://doi.org/10.1097/01.nmd.0000221303.64098.23

Couch, S. C., Glanz, K., Zhou, C., Sallis, J. F., & Saelens, B. E. (2014). Home food environment in relation to children's diet quality and weight status. *Journal of the Academy of Nutrition and Dietetics*, *114*(10), 1569-1579 e1561. https://doi.org/10.1016/j.jand.2014.05.015

Crawford, D., Ball, K., Mishra, G., Salmon, J., & Timperio, A. (2007). Which food-related behaviours are associated with healthier intakes of fruits and vegetables among women? *Public Health Nutrition*, *10*(3), 256-265. https://doi.org/10.1017/S1368980007246798

Cruise, C., Porter, L., Broderick, J., Kaell, A., & Stone, A. (1996). Reactive effects of diary self-assessment in chronic pain patients. *Pain*, *67*, 253-258.

Cruwys, T., Bevelander, K. E., & Hermans, R. C. (2014). Social modeling of eating: A review of when and why social influence affects food intake and choice. *Appetite*, *86*, 3-18. https://doi.org/10.1016/j.appet.2014.08.035

Dahlgren, G., & Whitehead, M. (1991). *Policies and strategies to promote social equity in health. Background document to WHO - Strategy paper for Europe*. WHO Collaborating Centre for Policy Research on Social Determinants of Health. https://ideas.repec.org/p/hhs/ifswps/2007_014.html

Davis, B., & Carpenter, C. (2009). Proximity of fast-food restaurants to schools and adolescent obesity. *American Journal of Public Health*, *99*(3), 505-510. https://doi.org/10.2105/AJPH.2008.137638

de Ridder, D., Kroese, F., Evers, C., Adriaanse, M., & Gillebaart, M. (2017). Healthy diet: Health impact, prevalence, correlates, and interventions. *Psychology & Health*, 32(8), 1-35. https://doi.org/10.1080/08870446.2017.1316849

de Vos, P., Hanck, C., Neisingh, M., Prak, D., Groen, H., & Faas, M. M. (2015). Weight gain in freshman college students and perceived health. *Preventive Medicine Reports*, *2*, 229-234. https://doi.org/10.1016/j.pmedr.2015.03.008

Deurenberg, P., & Yap, M. (1999). The assessment of obesity: Methods for measuring body fat and global prevalence of obesity. *Baillieres Best Practice & Research Clinical Endocrinology & Metabolism*, *13*(1), 1-11.

Ding, D., Sallis, J. F., Norman, G. J., Saelens, B. E., Harris, S. K., Kerr, J., Rosenberg, D., Durant, N., & Glanz, K. (2012). Community food environment, home food environment, and fruit and vegetable intake of children and adolescents. *Journal of Nutrition Education and Behavior*, *44*(6), 634-638. https://doi.org/10.1016/j.jneb.2010.07.003

Dixon, H., Scully, M., & Parkinson, K. (2006). Pester power: Snackfoods displayed at supermarkets checkouts in Melbourne, Australia. *Health Promotion Journal of Australia*, *17*(2), 124-127.

Dombrowski, S. U., Endevelt, R., Steinberg, D. M., & Benyamini, Y. (2016). Do more specific plans help you lose weight? Examining the relationship between plan specificity, weight loss goals, and plan content in the context of a weight management programme. *British Journal of Health Psychology*, *21*(4), 989-1005. https://doi.org/10.1111/bjhp.12212

Donker, T., Petrie, K., Proudfoot, J., Clarke, J., Birch, M. R., & Christensen, H. (2013). Smartphones for smarter delivery of mental health programs: a systematic review. *Journal of Medical Internet Research*, *15*(11), e247. https://doi.org/10.2196/jmir.2791

Duffey, K. J., & Popkin, B. M. (2011). Energy density, portion size, and eating occasions: contributions to increased energy intake in the United States, 1977-2006. *PLoS Medicine*, *8*(6), e1001050. https://doi.org/10.1371/journal.pmed.1001050

Dunton, G. F., Atienza, A. A., Castro, C. M., & King, A. C. (2009). Using ecological momentary assessment to examine antecedents and correlates of physical activity bouts in adults age 50+ years: a pilot study. *Annals of Behavioral Medicine*, *38*(3), 249-255. https://doi.org/10.1007/s12160-009-9141-4

Duresso, S. W., Bruno, R., Matthews, A. J., & Ferguson, S. G. (2018). Khat withdrawal symptoms among chronic khat users following a quit attempt: An Ecological Momentary Assessment study. *Psychology of Addictive Behaviors*, *32*(3), 320-326. https://doi.org/10.1037/adb0000368

Elizabeth, L., Machado, P., Zinocker, M., Baker, P., & Lawrence, M. (2020). Ultra-processed foods and health outcomes: A narrative review. *Nutrients*, *12*(7). https://doi.org/10.3390/nu12071955

Elliston, K. G., Ferguson, S. G., & Schüz, B. (2017). Personal and situational predictors of everyday snacking: An application of Temporal Self-regulation Theory. *British Journal of Health Psychology*, *22*(4). https://doi.org/10.1111/bjhp.12259

Elliston, K. G., Ferguson, S. G., Schüz, N., & Schüz, B. (2016). Situational cues and momentary food environment predict everyday eating behavior in adults with overweight and obesity. *Health Psychology*. https://doi.org/10.1037/hea0000439

Elliston, K. G., Schüz, B., Albion, T., & Ferguson, S. G. (2020). Comparison of Geographic Information System and subjective assessments of momentary food environments as predictors of food intake: An Ecological Momentary Assessment study. *JMIR Mhealth Uhealth*, *8*(7), e15948. https://doi.org/10.2196/15948

Emery, C. F., Olson, K. L., Lee, V. S., Habash, D. L., Nasar, J. L., & Bodine, A. (2015). Home environment and psychosocial predictors of obesity status among community-residing men and women. *International Journal of Obesity*, *39*(9), 1401-1407. https://doi.org/10.1038/ijo.2015.70

Enders, C. K., & Tofighi, D. (2007). Centering predictor variables in cross-sectional multilevel models: A new look at an old issue. *Psychological Methods*, *12*(2), 121-138. https://doi.org/10.1037/1082-989X.12.2.121

ESRI. (2019). *ArcMap*. Environmental Systems Reserch Institute. Retrieved July 23 from http://desktop.arcgis.com/en/arcmap/

Evans, R., Norman, P., & Webb, T. L. (2017). Using Temporal Self-Regulation Theory to understand healthy and unhealthy eating intentions and behaviour. *Appetite*, *116*, 357-364. https://doi.org/10.1016/j.appet.2017.05.022

Evers, C., Adriaanse, M., de Ridder, D. T., & de Witt Huberts, J. C. (2013). Good mood food. Positive emotion as a neglected trigger for food intake. *Appetite*, *68*, 1-7. https://doi.org/10.1016/j.appet.2013.04.007

Evers, C., de Ridder, D. T. D., & Adriaanse, M. A. (2009). Assessing yourself as an emotional eater: Mission impossible? *Health Psychology*, *28*(6), 717-725. https://doi.org/10.1037/a0016700

Evers, C., Dingemans, A., Junghans, A. F., & Boeve, A. (2018). Feeling bad or feeling good, does emotion affect your consumption of food? A meta-analysis of the experimental evidence. *Neuroscience and Biobehavioral Reviews*, *92*, 195-208. https://doi.org/10.1016/j.neubiorev.2018.05.028

Fayet-Moore, F., Peters, V., McConnell, A., Petocz, P., & Eldridge, A. L. (2017). Weekday snacking prevalence, frequency, and energy contribution have increased while foods consumed during snacking have shifted among Australian children and adolescents: 1995, 2007 and 2011-12 National Nutrition Surveys. *Nutrition Journal*, *16*(1), 65. https://doi.org/10.1186/s12937-017-0288-8

Ferguson, S. G., Jahnel, T., Elliston, K. G., & Shiffman, S. (2020). Ambulatory Assessment. In A. Wright & M. Hallquist (Eds.), *The Cambridge Handbook of Research Methods in Clinical Psychology* (pp. 301-311). Cambridge University Press. https://doi.org/10.1017/9781316995808.029

Ferguson, S. G., & Shiffman, S. (2011). Using the methods of Ecological Momentary Assessment in substance dependence research--smoking cessation as a case study. *Substance Use and Misuse*, *46*(1), 87-95. https://doi.org/10.3109/10826084.2011.521399

Ferriday, D., & Brunstrom, J. M. (2011). 'I just can't help myself': effects of food-cue exposure in overweight and lean individuals. *International Journal of Obesity*, *35*(1), 142-149. https://doi.org/10.1038/ijo.2010.117

Finucane, M. M., Stevens, G. A., Cowan, M. J., Danaei, G., Lin, J. K., Paciorek, C. J., Singh, G. M., Gutierrez, H. R., Lu, Y., Bahalim, A. N., Farzadfar, F., Riley, L. M., & Ezzati, M. (2011). National, regional, and global trends in body-mass index since 1980: Systematic analysis of health examination surveys and epidemiological studies with 960 country-years and 9·1 million participants. *The Lancet*, *377*(9765), 557-567. https://doi.org/10.1016/s0140-6736(10)62037-5

Forman, E. M., Goldstein, S. P., Zhang, F., Evans, B. C., Manasse, S. M., Butryn, M. L., Juarascio, A. S., Abichandani, P., Martin, G. J., & Foster, G. D. (2018). OnTrack: development and feasibility of a smartphone app designed to predict and prevent dietary lapses. *Translational Behavioral Medicine*. https://doi.org/10.1093/tbm/iby016

Forman, E. M., Schumacher, L. M., Crosby, R., Manasse, S. M., Goldstein, S. P., Butryn, M. L., Wyckoff, E. P., & Graham Thomas, J. (2017). Ecological Momentary Assessment of dietary lapses across behavioral weight loss treatment: Characteristics, predictors, and relationships with weight change. *Annals of Behavioral Medicine*. https://doi.org/10.1007/s12160-017-9897-x

Fox, S., Conneely, S., & Egan, J. (2017). Emotional expression and eating in overweight and obesity. *Health Psychology and Behavioral Medicine*, *5*(1), 337-357. https://doi.org/10.1080/21642850.2017.1378580

Frandsen, M., Thow, M., & Ferguson, S. G. (2016). The effectiveness of social media (Facebook) compared with more traditional advertising methods for recruiting eligible participants to health research etudies: A randomized, controlled clinical trial. *JMIR Research Protocols*, *5*(3), e161. https://doi.org/10.2196/resprot.5747

Frandsen, M., Walters, J., & Ferguson, S. G. (2014). Exploring the viability of using online social media advertising as a recruitment method for smoking cessation clinical trials. *Nicotine & Tobacco Research*, *16*(2), 247-251. https://doi.org/10.1093/ntr/ntt157

Franja, S., Elliston, K. G., & Ferguson, S. G. (2020). Body Mass Index and stimulus control: Results from a real-world study of eating behaviour. *Appetite*, *154*, 104783. https://doi.org/10.1016/j.appet.2020.104783

Frank, L. D., Andresen, M. A., & Schmid, T. L. (2004). Obesity relationships with community design, physical activity, and time spent in cars. *American Journal of Preventive Medicine*, *27*(2), 87-96. https://doi.org/10.1016/j.amepre.2004.04.011

French, S., Jeffery, R. W., Story, M., Breitlow, K., Baxter, J., Hannan, P., & Snyder, P. (2001). Pricing and promotion effects on low-fat vending snack purchases: The CHIPS study. *American Journal of Public Health*, *91*(1), 112-117.

Frye, W. S., & Shapiro, S. K. (2020). The role of executive functioning on the intention-behaviour relationship of health behaviours: A Temporal Self-regulatory perspective. *Psychology & Health*, 1-16. https://doi.org/10.1080/08870446.2020.1767778

Fuzhong, L., Harmer, P., Cardinal, B., Bosworth, M., Acock, A., Johnson-Shelton, D., & Moore, J. (2008). Built environment, adiposity, and physical activity in adults aged 50-75. *American Journal of Preventive Medicine*, *35*(1), 38-46.

Fuzhong, L., Harmer, P., Cardinal, B., Bosworth, M., & Johnson-Shelton, D. (2009). Obesity and the Built Environment: Does the Density of Neighborhood Fast-Food Outlets Matter? *American Journal of Health Promotion*, *23*(3), 203-209. https://doi.org/10.4278/ajhp.071214133

Garcia, K., & Mann, T. (2003). From 'I Wish' to 'I Will': social-cognitive predictors of behavioral intentions. *Journal of Health Psychology*, *8*(3), 347-360. https://doi.org/10.1177/13591053030083005

Garner, D., & Garfinkel, P. (1979). The Eating Attitudes Test: An index of the symptoms of anorexia nervosa. *Psychological Medicine, 9*, 273-279. https://doi.org/10.1017/s0033291700030762

Gearhardt, A. N., Corbin, W. R., & Brownell, K. D. (2009). Preliminary validation of the Yale Food Addiction Scale. *Appetite*, *52*(2), 430-436. https://doi.org/10.1016/j.appet.2008.12.003

Gibson, E. L. (2012). The psychobiology of comfort eating: Implications for neuropharmacological interventions. *Behavioural Pharmacology*, *23*(5-6), 442-460. https://doi.org/10.1097/FBP.0b013e328357bd4e

Giles-Corti, B., Macintyre, S., Clarkson, J., Pikora, T., & Donovan, R. (2003). Environmental and lifestyle factors associated with overweight and obesity in Perth, Australia. *The Science of Health Promotion*, *18*(1), 93-103.

Glanz, K., Bader, M. D., & Iyer, S. (2012). Retail grocery store marketing strategies and obesity: An integrative review. *American Journal of Preventive Medicine*, *42*(5), 503-512. https://doi.org/10.1016/j.amepre.2012.01.013

Glanz, K., Basil, M., Maibach, E., Goldberg, J., & Snyder, D. A. N. (1998). Why Americans Eat What They Do. *Journal of the American Dietetic Association*, *98*(10), 1118-1126. https://doi.org/10.1016/s0002-8223(98)00260-0

Glanz, K., Sallis, J. F., Saelens, B. E., & Frank, L. D. (2005). Healthy nutrition environments: Concepts and measures. *American Journal of Health Promotion*, *19*(5), 330-333.

Glanz, K., & Yaroch, A. L. (2004). Strategies for increasing fruit and vegetable intake in grocery stores and communities: Policy, pricing, and environmental change. *Preventive Medicine, 39 Suppl 2,* S75-80. https://doi.org/10.1016/j.ypmed.2004.01.004

Goldschmidt, A. B., Crosby, R. D., Cao, L., Engel, S. G., Durkin, N., Beach, H. M., Berg, K. C., Wonderlich, S. A., Crow, S. J., & Peterson, C. B. (2014). Ecological momentary assessment of eating episodes in obese adults. *Psychosomatic Medicine*, *76*(9), 747-752. https://doi.org/10.1097/PSY.0000000000000108

Goldschmidt, A. B., Wonderlich, S. A., Crosby, R. D., Engel, S. G., Lavender, J. M., Peterson, C. B., Crow, S. J., Cao, L., & Mitchell, J. E. (2014). Ecological Momentary Assessment of stressful events and negative affect in bulimia nervosa. *Journal of Consulting and Clinical Psychology*, *82*(1), 30-39. https://doi.org/10.1037/a0034974

Goldstein, S. P., Dochat, C., Schumacher, L. M., Manasse, S. M., Crosby, R. D., Thomas, J. G., Butryn, M. L., & Forman, E. M. (2018). Using Ecological Momentary Assessment to better understand dietary lapse types. *Appetite*, *129*, 198-206. https://doi.org/10.1016/j.appet.2018.07.003

Gollwitzer, P. M. (1999). Implementation intentions: Strong effects of simple plans. *American Psychologist*, *54*(7), 493-503.

Gorin, A. A., Phelan, S., Raynor, H., & Wing, R. (2011). Home food and exercise environments of normal-weight and overweight adults. *American Journal of Health Behavior*, *35*(5), 618-626. doi: 10.5993/ajhb.35.5.10.

Greenwald, A. (2006). Current nutritional treatments of obesity. *Advances in Psychosomatic Medicine*, *27*, 24-41. https://doi.org/10.1159/000090961

Grenard, J. L., Stacy, A. W., Shiffman, S., Baraldi, A. N., MacKinnon, D. P., Lockhart, G., Kisbu-Sakarya, Y., Boyle, S., Beleva, Y., Koprowski, C., Ames, S. L., & Reynolds, K. D. (2013). Sweetened drink and snacking cues in adolescents: a study using ecological momentary assessment. *Appetite*, *67*, 61-73. https://doi.org/10.1016/j.appet.2013.03.016

Groesz, L. M., McCoy, S., Carl, J., Saslow, L., Stewart, J., Adler, N., Laraia, B., & Epel, E. (2012). What is eating you? Stress and the drive to eat. *Appetite*, *58*(2), 717-721. https://doi.org/10.1016/j.appet.2011.11.028

Gudzune, K. A., Doshi, R. S., Mehta, A. K., Chaudhry, Z. W., Jacobs, D. K., Vakil, R. M., Lee, C. J., Bleich, S. N., & Clark, J. M. (2015). Efficacy of commercial weight-loss programs: an updated systematic review. *Annals of Internal Medicine*, *162*(7), 501-512. https://doi.org/10.7326/M14-2238

Gustafson, D. H., McTavish, F. M., Chih, M.-Y., Atwood, A. K., Johnson, R. A., Boyle, M. G., Levy, M. S., Driscoll, H., Chisholm, S. M., Dillenburg, L., Isham, A., & Shah, D. (2014). A Smartphone Application to Support Recovery From Alcoholism. *JAMA Psychiatry*, *71*(5). https://doi.org/10.1001/jamapsychiatry.2013.4642

Haedt-Matt, A. A., & Keel, P. K. (2011). Revisiting the affect regulation model of binge eating: A meta-analysis of studies using Ecological Momentary Assessment. *Psychological Bulletin*, *137*(4), 660-681. https://doi.org/10.1037/a0023660

Hagger, M. S., Wood, C., Stiff, C., & Chatzisarantis, N. L. D. (2009). The strength model of self-regulation failure and health-related behaviour. *Health Psychology Review*, *3*(2), 208-238. https://doi.org/10.1080/17437190903414387

Hall, P. A., & Fong, G. T. (2007). Temporal Self-regulation Theory: A model for individual health behavior. *Health Psychology Review*, *1*(1), 6-52. https://doi.org/10.1080/17437190701492437

Hall, P. A., & Fong, G. T. (2015). Temporal Self-regulation Theory: A neurobiologically informed model for physical activity behavior. *Frontiers in Human Neuroscience*, *9*, 117. https://doi.org/10.3389/fnhum.2015.00117

Hammersley, R. (1994). A digest of memory phenomena for addiction research. *Addiction*, *89*(3), 283-293. https://doi.org/10.1111/j.1360-0443.1994.tb00890.x

Hampl, J., Heaton, C., & Taylor, C. (2003). Snacking patterns influence energy and nutrient intakes but not body mass index. *Journal of Human Nutrition and Dietetics, 16,* 3-11. https://doi.org/10.1046/j.1365-277X.2003.00417.x

Harris, J. L., Bargh, J. A., & Brownell, K. D. (2009). Priming effects of television food advertising on eating behavior. *Health Psychology*, *28*(4), 404-413. https://doi.org/10.1037/a0014399

Hawkes, C. (2008). Dietary implications of supermarket development: A global perspective. *Development Policy Review, 26*(6), 657-692. https://doi.org/10.1111/j.1467-7679.2008.00428.x

He, M., Tucker, P., Gilliland, J., Irwin, J. D., Larsen, K., & Hess, P. (2012). The influence of local food environments on adolescents' food purchasing behaviors. *International Journal of Environmental Research and Public Health, 9*(4), 1458-1471. https://doi.org/10.3390/ijerph9041458

Heatherson, T., & Baumeister, R. F. (1991). Bing eating as escape from self-awareness. *Psychological Bulletin*, *10*(1), 86-108.

Hebert, J. R., Clemow, L., Pbert, L., Ockene, I. S., & Ockene, J. K. (1995). Social desirability bias in dietary self-report may comprimise the validity of dietary intake measures. *International Journal of Epidemiology, 24*(2), 389-398.

Heitmann, B., & Lissner, L. (1995). Dietary underreporting by obese individuals-is it specific or non-specific? *British Medical Journal*, *311*, 986-989.

Hendrie, G., Batrd, D., Golley, S., & Noakes, M. (2016). *CSIRO Healthy Diet Score 2016*. Retried March 3, 2017 from https://www.csiro.au/en/Research/Health/CSIRO-diets/Dietary-tools/CSIRO-Healthy-Diet-Score

Hepworth, R., Mogg, K., Brignell, C., & Bradley, B. P. (2010). Negative mood increases selective attention to food cues and subjective appetite. *Appetite*, *54*(1), 134-142. https://doi.org/10.1016/j.appet.2009.09.019

Herman, C. P., Fitzgerald, N. E., & Polivy, J. (2003). The influence of social norms on hunger ratings and eating. *Appetite*, *41*(1), 15-20. https://doi.org/10.1016/s0195-6663(03)00027-8

Herman, C. P., & Polivy, J. (2005). Normative influences on food intake. *Physiology and Behavior*, *86*(5), 762-772. https://doi.org/10.1016/j.physbeh.2005.08.064

Hermans, R. C., Larsen, J. K., Herman, C. P., & Engels, R. C. (2009). Effects of social modeling on young women's nutrient-dense food intake. *Appetite*, *53*(1), 135-138. https://doi.org/10.1016/j.appet.2009.05.004

Heshka, S., Greenway, F., Anderson, J. W., Atkinson, R. L., Hill, J. O., Phinney, S. D., Miller-Kovach, K., & Xavier Pi-Sunyer, F. (2000). Self-help weight loss versus a structured commercial program after 26 weeks: A randomized controlled study. *The American Journal of Medicine*, *109*(4), 282-287. https://doi.org/10.1016/s0002-9343(00)00494-0

Higgs, S. (2015). Social norms and their influence on eating behaviours. *Appetite*, *86*, 38-44. https://doi.org/10.1016/j.appet.2014.10.021

Higgs, S., Liu, J., Collins, E. I. M., & Thomas, J. M. (2019). Using social norms to encourage healthier eating. *Nutrition Bulletin*, *44*(1), 43-52. https://doi.org/10.1111/nbu.12371

Higgs, S., & Thomas, J. (2016). Social influences on eating. *Current Opinion in Behavioral Sciences*, *9*, 1-6. https://doi.org/10.1016/j.cobeha.2015.10.005

Hill, J., & Peters, J. (1998). Environmental Contributions to the Obesity Epidemic. *Science*, *280*, 1371-1374.

Hill, S. E., Baskett, K., Bradshaw, H. K., Prokosch, M. L., DelPriore, D. J., & Rodeheffer, C. D. (2016). Tempting foods and the affordability axiom: Food cues change beliefs about the costs of healthy eating. *Appetite*, *107*, 274-279. https://doi.org/10.1016/j.appet.2016.08.014

Hillier-Brown, F. C., Moore, H. J., Lake, A. A., Adamson, A. J., White, M., Adams, J., Araujo-Soares, V., Abraham, C., & Summerbell, C. D. (2014). The effectiveness of interventions targeting specific out-of-home food outlets: protocol for a systematic review. *Systematic Reviews*, *3*, 17. https://doi.org/10.1186/2046-4053-3-17

Hofmann, W., Adriaanse, M., Vohs, K. D., & Baumeister, R. F. (2014). Dieting and the self-control of eating in everyday environments: An experience sampling study. *British Journal of Health Psychology*, *19*(3), 523-539. https://doi.org/10.1111/bjhp.12053

Hofmann, W., Baumeister, R. F., Forster, G., & Vohs, K. D. (2012). Everyday temptations: An experience sampling study of desire, conflict, and self-control. *Journal of Personality and Social Psychology*, *102*(6), 1318-1335. https://doi.org/10.1037/a0026545

Hofmann, W., Rauch, W., & Gawronski, B. (2007). And deplete us not into temptation: Automatic attitudes, dietary restraint, and self-regulatory resources as determinants of eating behavior. *Journal of Experimental Social Psychology*, *43*(3), 497-504. https://doi.org/10.1016/j.jesp.2006.05.004

Holland, R. W., Aarts, H., & Langendam, D. (2006). Breaking and creating habits on the working floor: A field-experiment on the power of implementation intentions. *Journal of Experimental Social Psychology*, *42*(6), 776-783. https://doi.org/10.1016/j.jesp.2005.11.006

Hox, J. J. (2010). *Multilevel analysis: Techniques and applications* (2nd ed.). Erlbaum, Mahwah, NJ.

Hufford, M. R., Shields, A. L., Shiffman, S., Paty, J., & Balabanis, M. (2002). Reactivity to ecological momentary assessment: An example using undergraduate problem drinkers. *Psychology of Addictive Behaviors*, *16*(3), 205-211. doi:10.1037//0893-164x.16.3.205

Inagami, S., Cohen, D. A., Brown, A. F., & Asch, S. M. (2009). Body mass index, neighborhood fast food and restaurant concentration, and car ownership. *Journal of Urban Health*, *86*(5), 683-695. https://doi.org/10.1007/s11524-009-9379-y

Jahnel, T., Ferguson, S. G., Shiffman, S., Thrul, J., & Schüz, B. (2017). Momentary smoking context as a mediator of the relationship between SES and smoking. *Addictive Behaviors*, *83,* https://doi.org/10.1016/j.addbeh.2017.12.014

Jahns, L., Conrad, Z., Johnson, L. K., Scheett, A. J., Stote, K. S., & Raatz, S. K. (2017). Diet quality is lower and energy intake is higher on weekends compared with weekdays in midlife women: A 1-year cohort study. *Journal of the Academy of Nutrition and Dietetics*, *117*(7), 1080-1086 e1081. https://doi.org/10.1016/j.jand.2017.01.012

Jansen, A. (1998). A learning model of binge eating: Cue reactivity and cue exposure. *Behaviour Research and Therapy*, *36*(3), 257-272. https://doi.org/10.1016/S0005-7967(98)00055-2

Jeffery, R. W., Baxter, J., McGuire, M., & Linde, J. (2006). Are fast food restaurants an environmental risk factor for obesity? *The International Journal of Behavioral Nutrition and Physical Activity*, *3*, 2. https://doi.org/10.1186/1479-5868-3-2

Jeffers, A. J., Mason, T. B., & Benotsch, E. G. (2019). Psychological eating factors, affect, and ecological momentary assessed diet quality. *Eating and Weight*

Disorders - Studies on Anorexia, Bulimia and Obesity, *25*(5), 1151-1159. https://doi.org/10.1007/s40519-019-00743-3

Jiao, J., Moudon, A. V., Kim, S. Y., Hurvitz, P. M., & Drewnowski, A. (2015). Health implications of adults' eating at and living near fast food or quick service restaurants. *Nutrition & Diabetes*, *5*, e171. https://doi.org/10.1038/nutd.2015.18

Johansson, L., Solvoll, K., Bjørneboe, G., & Drevon, C. (1998). Under- and overreporting of energy intake related to weight-status and lifestyle in a nationwide sample. *The American Journal of Clinical Nutrition*, *68*, 266-274.

Kachurak, A., Davey, A., Bailey, R. L., & Fisher, J. O. (2018). Daily snacking occasions and weight status among US children aged 1 to 5 years. *Obesity (Silver Spring)*, *26*(6), 1034-1042. https://doi.org/10.1002/oby.22172

Kaisari, P., & Higgs, S. (2015). Social modelling of food intake. The role of familiarity of the dining partners and food type. *Appetite*, *86*, 19-24. https://doi.org/10.1016/j.appet.2014.09.020

Kaplan, R. M., & Stone, A. A. (2013). Bringing the laboratory and clinic to the community: Mobile technologies for health promotion and disease prevention. *Annual Review of Psychology*, *64*, 471-498. https://doi.org/10.1146/annurev-psych-113011-143736

Keller, C., Hartmann, C., & Siegrist, M. (2016). The association between dispositional self-control and longitudinal changes in eating behaviors, diet quality, and BMI. *Psychology & Health*, *31*(11), 1311-1327. https://doi.org/10.1080/08870446.2016.1204451

Kemps, E., Tiggemann, M., & Hollitt, S. (2014). Exposure to television food advertising primes food-related cognitions and triggers motivation to eat. *Psychology & Health*, *29*(10), 1192-1205. https://doi.org/10.1080/08870446.2014.918267

Kestens, Y., Lebel, A., Chaix, B., Clary, C., Daniel, M., Pampalon, R., Theriault, M., & SV, P. S. (2012). Association between activity space exposure to food establishments and individual risk of overweight. *PloS One*, *7*(8), e41418. https://doi.org/10.1371/journal.pone.0041418

King, B. M. (2013). The modern obesity epidemic, ancestral hunter-gatherers, and the sensory/reward control of food intake. *American Psychologist*, *68*(2), 88-96. https://doi.org/10.1037/a0030684

King, T., Kavanagh, A. M., Jolley, D., Turrell, G., & Crawford, D. (2006). Weight and place: A multilevel cross-sectional survey of area-level social disadvantage and overweight/obesity in Australia. *International Journal of Obesity*, *30*(2), 281-287. https://doi.org/10.1038/sj.ijo.0803176

Kitsantas, A. (2000). The role of self-regulation strategies and self-efficacy perceptions in successful weight loss maintenance. *Psychology & Health*, *15*(6), 811-820. https://doi.org/10.1080/08870440008405583

Kremers, S. P., de Bruijn, G. J., Visscher, T. L., van Mechelen, W., de Vries, N. K., & Brug, J. (2006). Environmental influences on energy balance-related behaviors: a dual-process view. *The International Journal of Behavioral Nutrition and Physical Activity*, *3*, 9. https://doi.org/10.1186/1479-5868-3-9

Kruglanski, A. W., Shah, J. Y., Fishbach, A., Friedman, R., Woo Young, C., & Sleeth-Keppler, D. (2002). A theory of goal systems. *Advances in Experimental Social Psychology*, 34, 331-378. https://doi.org/10.1016/s0065-2601(02)80008-9

Laing, B. Y., Mangione, C. M., Tseng, C. H., Leng, M., Vaisberg, E., Mahida, M., Bholat, M., Glazier, E., Morisky, D. E., & Bell, D. S. (2014). Effectiveness of a smartphone application for weight loss compared with usual care in overweight primary care patients: A randomized, controlled trial. *Annals of Internal Medicine*, *161*(10 Suppl), S5-12. https://doi.org/10.7326/M13-3005

Lake, A., & Townshend, T. (2006). Obesogenic environments: Exploring the built and food environments. *The Journal of the Royal Society for the Promotion of Health*, *126*(6), 262-267. https://doi.org/10.1177/1466424006070487

Larson, R. (2006). Core principles for supermarket aisle management. *Journal of Food Distribution Research*, *37*(1), 101-105. doi: 10.22004/ag.econ.8554

Lawrence, M. A., Dickie, S., & Woods, J. L. (2018). Do nutrient-based front-of-pack labelling schemes support or undermine food-based dietary guideline recommendations? Lessons from the Australian Health Star Rating System. *Nutrients*, *10*(1). https://doi.org/10.3390/nu10010032

Lean, M. E., Anderson, A. S., Morrison, C., & Currall, J. (2003). Evaluation of a dietary targets monitor. *European Journal of Clinical Nutrition, 57*(5), 667-673. https://doi.org/10.1038/sj.ejcn.1601596

Lee, P. C., & Dixon, J. B. (2017). Food for thought: Reward mechanisms and hedonic overeating in obesity. *Current Obesity Reports,* 6. https://doi.org/10.1007/s13679-017-0280-9

Liao, Y., Schembre, S. M., O'Connor, S. G., Belcher, B. R., Maher, J. P., Dzubur, E., & Dunton, G. F. (2018). An electronic Ecological Momentary Assessment study to examine the consumption of high-fat/high-sugar foods, fruits/vegetables, and affective states among women. *Journal of Nutrition Education and Behavior*, *50*(6), 626-631. https://doi.org/10.1016/j.jneb.2018.02.003

Linas, B. S., Latkin, C., Westergaard, R. P., Chang, L. W., Bollinger, R. C., Genz, A., & Kirk, G. D. (2015). Capturing illicit drug use where and when it happens: An Ecological Momentary Assessment of the social, physical and activity environment of using versus craving illicit drugs. *Addiction*, *110*(2), 315-325. https://doi.org/10.1111/add.12768

Little, B. (1983). Personal projects: A rational method for investigation. *Environment and Behaviour*, *15*(3), 273-309.

Little, B. (2006). Personality science and self regulation: Personal projects as integrative units. *Applied Psychology: An International Review*, *53*(3), 419-427.

Lorenc, T., Petticrew, M., Welch, V., & Tugwell, P. (2013). What types of interventions generate inequalities? Evidence from systematic reviews. *Journal of Epidemiology and Community Health*, *67*(2), 190-193. https://doi.org/10.1136/jech-2012-201257

Lowe, M. R., & Butryn, M. L. (2007). Hedonic hunger: A new dimension of appetite? *Physiology and Behavior*, *91*(4), 432-439. https://doi.org/10.1016/j.physbeh.2007.04.006

Lowe, M. R., Butryn, M. L., Didie, E. R., Annunziato, R. A., Thomas, J. G., Crerand, C. E., Ochner, C. N., Coletta, M. C., Bellace, D., Wallaert, M., & Halford, J. (2009). The Power of Food Scale. A new measure of the psychological influence of the food environment. *Appetite*, *53*(1), 114-118. https://doi.org/10.1016/j.appet.2009.05.016

Lucan, S. C., & Mitra, N. (2012). Perceptions of the food environment are associated with fast-food (not fruit-and-vegetable) consumption: Findings from multi-level models. *International Journal of Public Health*, *57*(3), 599-608. https://doi.org/10.1007/s00038-011-0276-2

Lutter, M., & Nestler, E. J. (2009). Homeostatic and hedonic signals interact in the regulation of food intake. *Journal of Nutrition*, *139*(3), 629-632. https://doi.org/10.3945/jn.108.097618

Lytle, L. A., & Sokol, R. L. (2017). Measures of the food environment: A systematic review of the field, 2007-2015. *Health Place*, *44,* 18-34. https://doi.org/10.1016/j.healthplace.2016.12.007

Ma, X., Barnes, T. L., Freedman, D. A., Bell, B. A., Colabianchi, N., & Liese, A. D. (2013). Test-retest reliability of a questionnaire measuring perceptions of neighborhood food environment. *Health Place*, *21*, 65-69. https://doi.org/10.1016/j.healthplace.2013.01.008

Maas, C. J. M., & Hox, J. J. (2005). Sufficient sample sizes for multilevel modeling. *Methodology*, *1*(3), 86-92. https://doi.org/10.1027/1614-2241.1.3.86

Macht, M. (2008). How emotions affect eating: A five-way model. *Appetite*, *50*(1), 1-11. https://doi.org/10.1016/j.appet.2007.07.002

Maclure, M., & Mittleman, M. A. (2000). Should we use a case-crossover design? . *Annual Review of Public Health*, *21*, 193-221.

Mann, T., Tomiyama, A. J., Westling, E., Lew, A. M., Samuels, B., & Chatman, J. (2007). Medicare's search for effective obesity treatments: Diets are not the answer. *American Psychologist*, *62*(3), 220-233. https://doi.org/10.1037/0003-066X.62.3.220

Mason, T. B., Heron, K. E., Braitman, A. L., & Lewis, R. J. (2016). A daily diary study of perceived social isolation, dietary restraint, and negative affect in binge eating. *Appetite*, *97*, 94-100. https://doi.org/10.1016/j.appet.2015.11.027

McDermott, M. S., Oliver, M., Iverson, D., & Sharma, R. (2016). Effective techniques for changing physical activity and healthy eating intentions and behaviour: A systematic review and meta-analysis. *British Journal of Health Psychology*, *21*(4), 827-841. https://doi.org/10.1111/bjhp.12199

McDermott, M. S., Oliver, M., Simnadis, T., Beck, E. J., Coltman, T., Iverson, D., Caputi, P., & Sharma, R. (2015). The Theory of Planned Behaviour and dietary patterns: A systematic review and meta-analysis. *Preventive Medicine*, *81*, 150-156. https://doi.org/10.1016/j.ypmed.2015.08.020

McEvedy, S. M., Sullivan-Mort, G., McLean, S. A., Pascoe, M. C., & Paxton, S. J. (2017). Ineffectiveness of commercial weight-loss programs for achieving modest but meaningful weight loss: Systematic review and meta-analysis. *Journal of Health Psychology*, *22*(12), 1614-1627. https://doi.org/10.1177/1359105317705983

McFerran, B., Dahl, D., Fitzsimons, G., & Morales, A. (2010). I'll have what she's having: Effects of social influence and body type on the food choices of others. *Journal of Consumer Research*, *36*(6), 915-929. https://doi.org/10.1086/644611

McKee, H. C., Ntoumanis, N., & Taylor, I. M. (2014). An Ecological Momentary Assessment of lapse occurrences in dieters. *Annals of Behavioral Medicine*, *48*(3), 300-310. https://doi.org/10.1007/s12160-014-9594-y

Mollen, S., Rimal, R. N., Ruiter, R. A., & Kok, G. (2013). Healthy and unhealthy social norms and food selection. Findings from a field-experiment. *Appetite*, *65*, 83-89. https://doi.org/10.1016/j.appet.2013.01.020

Monteiro, L. S., Hassan, B. K., Estima, C. C. P., Souza, A. M., Verly, E. J., Sichieri, R., & Pereira, R. A. (2017). Food consumption according to the days of the week - National Food Survey, 2008-2009. *Revista de Saúde Publica*, *51*, 93. https://doi.org/10.11606/S1518-8787.2017051006053

Moore, L. V., Diez Roux, A. V., & Brines, S. (2008). Comparing perception-based and Geographic Information System (GIS)-based characterizations of the local food environment. *Journal of Urban Health*, *85*(2), 206-216. https://doi.org/10.1007/s11524-008-9259-x

Morland, K., Diez Roux, A. V., & Wing, S. (2006). Supermarkets, other food stores, and obesity: The atherosclerosis risk in communities study. *American Journal of Preventive Medicine*, *30*(4), 333-339. https://doi.org/10.1016/j.amepre.2005.11.003

Moskowitz, D., & Young, S. (2006). Ecological Momentary Assessment: What it is and why it is a method of the future in clinical psychopharmacology. *Journal of Psychiatry and Neuroscience*, *31*(1), 13-20.

Mullan, B., Allom, V., Fayn, K., & Johnston, I. (2014). Building habit strength: A pilot intervention designed to improve food-safety behavior. *Food Research International*, *66*, 274-278. https://doi.org/10.1016/j.foodres.2014.09.027

Murray, A. (2018). A faster taste: Red Rooster and the architecture of Australian fast food. *Historic Environment*, *30*(2), 100-111. https://search.informit.com.au/documentSummary;dn=142939227338238;res=IELAPA

Myin-Germeys, I., Oorschot, M., Collip, D., Lataster, J., Delespaul, P., & van Os, J. (2009). Experience sampling research in psychopathology: Opening the black box of daily life. *Psychological Medicine*, *39*(9), 1533-1547. https://doi.org/10.1017/S0033291708004947

Nahum-Shani, I., Smith, S. N., Spring, B. J., Collins, L. M., Witkiewitz, K., Tewari, A., & Murphy, S. A. (2018). Just-in-Time Adaptive Interventions (JITAIs) in mobile health: Key components and design principles for ongoing health behavior support. *Annals of Behavioral Medicine*, *52*(6), 446-462. https://doi.org/10.1007/s12160-016-9830-8

Nahum-Shani, S., Smith, S., Tewari, A., Witkiewitz, K., Collins, L. M., Spring, B., & Murphy, S. A. (2014). *Just-in-time adaptive interventions (JITAIs): An organizing framework for ongoing health behavior support*. The Methodology Center, Penn State, University Park, Pennsylvania.

Nakata, R., & Kawai, N. (2017). The "social" facilitation of eating without the presence of others: Self-reflection on eating makes food taste better and people eat more.

Physiology and Behavior, *179*, 23-29. https://doi.org/10.1016/j.physbeh.2017.05.022

Naughton, F. (2016). Delivering “Just-In-Time” smoking cessation support via mobile phones: Current knowledge and future directions. *Nicotine & Tobacco Research*, *19*(3), 379-383. https://doi.org/10.1093/ntr/ntw143

Naughton, F., Hopewell, S., Lathia, N., Schalbroeck, R., Brown, C., Mascolo, C., McEwen, A., & Sutton, S. (2016). A context-sensing mobile phone app (Q Sense) for smoking cessation: A mixed-methods study. *JMIR Mhealth Uhealth*, *4*(3), e106. https://doi.org/10.2196/mhealth.5787

Nederkoorn, C., Guerrieri, R., Havermans, R. C., Roefs, A., & Jansen, A. (2009). The interactive effect of hunger and impulsivity on food intake and purchase in a virtual supermarket. *International Journal of Obesity (2005)*, *33*(8), 905-912. https://doi.org/10.1038/ijo.2009.98

Nestle, M. (2002). *Food Politics: How the food industry influences nutrition and health*. University of California Press, Los Angeles.

Nestle, M. (2013). *Food politics: How the food industry influences nutrition and health* (10th ed.). University of California Press, Los Angeles.

Nestle, M., & Jacobson, M. (2000). Halting the Obesity Epidemic: A Public Health Policy Approach. *Public Health Reports*, *115*(1), 12-24. doi: 10.1093/phr/115.1.12

Nestle, M., Wing, R., Birch, L., DiSogra, L., Drewnowski, A., Arbor, A., Middleton, S., Sigman-Grant, M., Sobal, J., Winston, M., & Economos, C. (1998). Behavioral and Social Influences on Food Choice. *Nutrition Reviews*, *56*(5).

Neve, M., Morgan, P. J., & Collins, C. E. (2011). Weight change in a commercial web-based weight loss program and its association with website use: Cohort study.

Journal of Medical Internet Research, *13*(4), e83. https://doi.org/10.2196/jmir.1756

Ng, M., Fleming, T., Robinson, M., Thomson, B., Graetz, N., Margono, C., Mullany, E. C., Biryukov, S., Abbafati, C., Abera, S. F., Abraham, J. P., Abu-Rmeileh, N. M. E., Achoki, T., AlBuhairan, F. S., Alemu, Z. A., Alfonso, R., Ali, M. K., Ali, R., Guzman, N. A., Ammar, W., Anwari, P., Banerjee, A., Barquera, S., Basu, S., Bennett, D. A., Bhutta, Z., Blore, J., Cabral, N., Nonato, I. C., Chang, J.-C., Chowdhury, R., Courville, K. J., Criqui, M. H., Cundiff, D. K., Dabhadkar, K. C., Dandona, L., Davis, A., Dayama, A., Dharmaratne, S. D., Ding, E. L., Durrani, A. M., Esteghamati, A., Farzadfar, F., Fay, D. F. J., Feigin, V. L., Flaxman, A., Forouzanfar, M. H., Goto, A., Green, M. A., Gupta, R., Hafezi-Nejad, N., Hankey, G. J., Harewood, H. C., Havmoeller, R., Hay, S., Hernandez, L., Husseini, A., Idrisov, B. T., Ikeda, N., Islami, F., Jahangir, E., Jassal, S. K., Jee, S. H., Jeffreys, M., Jonas, J. B., Kabagambe, E. K., Khalifa, S. E. A. H., Kengne, A. P., Khader, Y. S., Khang, Y.-H., Kim, D., Kimokoti, R. W., Kinge, J. M., Kokubo, Y., Kosen, S., Kwan, G., Lai, T., Leinsalu, M., Li, Y., Liang, X., Liu, S., Logroscino, G., Lotufo, P. A., Lu, Y., Ma, J., Mainoo, N. K., Mensah, G. A., Merriman, T. R., Mokdad, A. H., Moschandreas, J., Naghavi, M., Naheed, A., Nand, D., Narayan, K. M. V., Nelson, E. L., Neuhouser, M. L., Nisar, M. I., Ohkubo, T., Oti, S. O., Pedroza, A., Prabhakaran, D., Roy, N., Sampson, U., Seo, H., Sepanlou, S. G., Shibuya, K., Shiri, R., Shiue, I., Singh, G. M., Singh, J. A., Skirbekk, V., Stapelberg, N. J. C., Sturua, L., Sykes, B. L., Tobias, M., Tran, B. X., Trasande, L., Toyoshima, H., van de Vijver, S., Vasankari, T. J., Veerman, J. L., Velasquez-Melendez, G., Vlassov, V. V., Vollset, S. E., Vos, T., Wang, C., Wang, X., Weiderpass, E., Werdecker, A., Wright, J. L., Yang, Y. C., Yatsuya, H., Yoon, J., Yoon, S.-J., Zhao, Y., Zhou, M., Zhu, S., Lopez, A. D., Murray, C. J. L., & Gakidou, E. (2014). Global, regional, and national prevalence of overweight and obesity in children and adults during 1980–2013: A systematic analysis for the Global Burden of Disease Study 2013. *The Lancet*, *384*(9945), 766-781. https://doi.org/10.1016/s0140-6736(14)60460-8

NHMRC. (2012). *Management of overweight and obesity in adults, adolescents and children*. Retrieved September 14, 2016 from https://consultations.nhmrc.gov.au/files/consultations/drafts/draftobesityguidelines120329.pdf

Ni Mhurchu, C., Vandevijvere, S., Waterlander, W., Thornton, L. E., Kelly, B., Cameron, A. J., Snowdon, W., Swinburn, B., & Informas. (2013). Monitoring the availability of healthy and unhealthy foods and non-alcoholic beverages in community and consumer retail food environments globally. *Obesity Reviews*, *14 Suppl 1*, 108-119. https://doi.org/10.1111/obr.12080

Norman, A., Kjellenberg, K., Torres Arechiga, D., Lof, M., & Patterson, E. (2020). "Everyone can take photos." Feasibility and relative validity of phone photography-based assessment of children's diets - a mixed methods study. *Nutrition Journal*, *19*(1), 50. https://doi.org/10.1186/s12937-020-00558-4

Nutrition Australia. (2016). *Try for 5… with a healthy balanced meal*. Retrieved October 23, 2019 from https://www.nutritionaustralia.org/national/national-nutrition-week/resources/try-5-healthy-balanced-meal

O'Connor, D., Jones, F., Conner, M., McMillan, B., & Ferguson, E. (2008). Effects of daily hassles and eating style on eating behavior. *Health Psychology*, *27*(1), S20-S31. https://doi.org/10.1037/0278-6133.27.1(Suppl.).S20

O'Connor, D. B., Armitage, C. J., & Ferguson, E. (2015). Randomized test of an implementation intention-based tool to reduce stress-induced eating. *Annals of*

Behavioral Medicine, *49*(3), 331-343. https://doi.org/10.1007/s12160-014-9668-x

O'Hara, B. J., Grunseit, A., Phongsavan, P., Bellew, W., Briggs, M., & Bauman, A. E. (2016). Impact of the Swap It, Don't Stop It Australian national mass media campaign on promoting small changes to lifestyle behaviors. *Journal of Health Communication*, *21*(12), 1276-1285. https://doi.org/10.1080/10810730.2016.1245803

O'Neill, D. (2015). Measuring obesity in the absence of a gold standard. *Economics and Human Biology*, *17*, 116-128. https://doi.org/10.1016/j.ehb.2015.02.002

Oliver, G., Wardle, J., & Gibson, L. (2000). Stress and food choice: A laboratory study. *Psychosomatic Medicine*, *62*(6), 853-865. doi: 10.1097/00006842-200011000-00016

Onwezen, M. C., Van 't Riet, J., Dagevos, H., Sijtsema, S. J., & Snoek, H. M. (2016). Snacking now or later? Individual differences in following intentions or habits explained by time perspective. *Appetite*, *107*, 144-151. https://doi.org/10.1016/j.appet.2016.07.031

Ouwehand, C., & Papies, E. K. (2010). Eat it or beat it. The differential effects of food temptations on overweight and normal-weight restrained eaters. *Appetite*, *55*(1), 56-60. https://doi.org/10.1016/j.appet.2010.04.009

Ovaskainen, M. L., Reinivuo, H., Tapanainen, H., Hannila, M. L., Korhonen, T., & Pakkala, H. (2006). Snacks as an element of energy intake and food consumption. *European Journal of Clinical Nutrition*, *60*(4), 494-501. https://doi.org/10.1038/sj.ejcn.1602343

Pagoto, S., Schneider, K., Jojic, M., DeBiasse, M., & Mann, D. (2013). Evidence-based strategies in weight-loss mobile apps. *American Journal of Preventive Medicine*, *45*(5), 576-582. https://doi.org/10.1016/j.amepre.2013.04.025

Papies, E. K. (2012). Goal priming in dieters: Recent insights and applications. *Current Obesity Reports*, *1*(2), 99-105. https://doi.org/10.1007/s13679-012-0009-8

Papies, E. K., & Stroebe, W. (2012). Dieting in a food-rich environment: Nonconscious mechanisms of self-regulatory failure and success. 114-134.

Papies, E. K., & Veling, H. (2013). Healthy dining. Subtle diet reminders at the point of purchase increase low-calorie food choices among both chronic and current dieters. *Appetite*, *61*(1), 1-7. https://doi.org/10.1016/j.appet.2012.10.025

Parker, G., Parker, I., & Brotchie, H. (2006). Mood state effects of chocolate. *Journal of Affective Disorders*, *92*(2-3), 149-159. https://doi.org/10.1016/j.jad.2006.02.007

Payne, C., & Niculescu, M. (2018). Can healthy checkout end-caps improve targeted fruit and vegetable purchases? Evidence from grocery and SNAP participant purchases. *Food Policy*, *79*, 318-323. https://doi.org/10.1016/j.foodpol.2018.03.002

Peacock, A., Cash, C., Bruno, R., & Ferguson, S. G. (2015). Day-by-day variation in affect, arousal and alcohol consumption in young adults. *Drug and Alcohol Review*, *34*(6), 588-594. https://doi.org/10.1111/dar.12238

Piernas, C., & Popkin, B. M. (2010). Snacking increased among U.S. adults between 1977 and 2006. *Journal of Nutrition*, *140*(2), 325-332. https://doi.org/10.3945/jn.109.112763

Pitt, E., Gallegos, D., Comans, T., Cameron, C., & Thornton, L. (2017). Exploring the influence of local food environments on food behaviours: A systematic review of qualitative literature. *Public Health Nutrition*, *20*(13), 2393-2405. https://doi.org/10.1017/S1368980017001069

Polacsek, M., Moran, A., Thorndike, A. N., Boulos, R., Franckle, R. L., Greene, J. C., Blue, D. J., Block, J. P., & Rimm, E. B. (2018). A Supermarket Double-Dollar Incentive Program Increases Purchases of Fresh Fruits and Vegetables Among

Low-Income Families With Children: The Healthy Double Study. *Journal of Nutrition Education and Behavior*, *50*(3), 217-228 e211. https://doi.org/10.1016/j.jneb.2017.09.013

Pollard, J., Kirk, S. F., & Cade, J. E. (2002). Factors affecting food choice in relation to fruit and vegetable intake: a review. *Nutrition Research Reviews*, *15*(2), 373-387. https://doi.org/10.1079/NRR200244

Popkin, B. M., Adair, L. S., & Ng, S. W. (2012). Global nutrition transition: The pandemic of obesity in developing countries. *Nutrition Reviews*, *70*(1), 3-21. https://doi.org/10.1111/j.1753-4887.2011.00456.x

Presseau, J., Sniehotta, F. F., Francis, J. J., & Gebhardt, W. A. (2010). With a little help from my goals: Integrating intergoal facilitation with the Theory of Planned Behaviour to predict physical activity. *British Journal of Health Psychology*, *15*(Pt 4), 905-919. https://doi.org/10.1348/135910710X494105

Presseau, J., Tait, R. I., Johnston, D. W., Francis, J. J., & Sniehotta, F. F. (2013). Goal conflict and goal facilitation as predictors of daily accelerometer-assessed physical activity. *Health Psychology*, *32*(12), 1179-1187. https://doi.org/10.1037/a0029430

Prinsen, S., de Ridder, D. T., & de Vet, E. (2013). Eating by example. Effects of environmental cues on dietary decisions. *Appetite*, *70*, 1-5. https://doi.org/10.1016/j.appet.2013.05.023

Pulos, E., & Leng, K. (2010). Evaluation of a voluntary menu labeling program in full-service restaurants. *American Journal of Public Health*, *100*(6). https://doi.org/10.2105/AJPH.2009

PwC Australia. (2015). *Weighing the cost of obesity: A case for action*. Retrieved January 20, 2019 from https://www.pwc.com.au/publications/healthcare-obesity.html

Raghunathan, R., Walker Naylor, R., & Hoyer. W. (2006). The unhealthy = tasty intuition and its effects on taste inferences, enjoyment, and choice of food products. *Journal of Marketing*, *70*(4), 170-184. https://doi.org/10.1509/jmkg.70.4.170

Rangan, A. M., Schindeler, S., Hector, D. J., Gill, T. P., & Webb, K. L. (2009). Consumption of 'extra' foods by Australian adults: Types, quantities and contribution to energy and nutrient intakes. *European Journal of Clinical Nutrition*, *63*(7), 865-871. https://doi.org/10.1038/ejcn.2008.51

Raspopow, K., Matheson, K., Abizaid, A., & Anisman, H. (2013). Unsupportive social interactions influence emotional eating behaviors. The role of coping styles as mediators. *Appetite, 62*, 143-149. https://doi.org/10.1016/j.appet.2012.11.031

Raulio, S., Roos, E., & Prattala, R. (2010). School and workplace meals promote healthy food habits. *Public Health Nutrition*, *13*(6A), 987-992. https://doi.org/10.1017/S1368980010001199

Reichenberger, J., Pannicke, B., Arend, A. K., Petrowski, K., & Blechert, J. (2020). Does stress eat away at you or make you eat? EMA measures of stress predict day to day food craving and perceived food intake as a function of trait stress-eating. *Psychology & Health*, 1-19. https://doi.org/10.1080/08870446.2020.1781122

Reicks, M., Davey, C., Anderson, A. K., Banna, J., Cluskey, M., Gunther, C., Jones, B., Richards, R., Topham, G., & Wong, S. S. (2019). Frequency of eating alone is associated with adolescent dietary intake, perceived food-related parenting practices and weight status: cross-sectional Family Life, Activity, Sun, Health, and Eating (FLASHE) Study results. *Public Health Nutrition, 22*(9), 1555-1566. https://doi.org/10.1017/S1368980019000107

Reidpath, D., Burns, C., Garrard, J., Mahoney, M., & Townsend, M. (2002). An ecological study of the relationship between social and environmental determinants of obesity. *Health & Place 8*(2), 141-145. doi: 10.1016/s1353-8292(01)00028-4.

Richard, A., Meule, A., Reichenberger, J., & Blechert, J. (2017). Food cravings in everyday life: An EMA study on snack-related thoughts, cravings, and consumption. *Appetite, 113*, 215-223. https://doi.org/10.1016/j.appet.2017.02.037

Riediger, M., & Freund, A. M. (2004). Interference and facilitation among personal goals: differential associations with subjective well-being and persistent goal pursuit. *Personality and Social Psychology Bulletin, 30*(12), 1511-1523. https://doi.org/10.1177/0146167204271184

Roberts, S. B., Das, S. K., Suen, V. M. M., Pihlajamäki, J., Kuriyan, R., Steiner-Asiedu, M., Taetzsch, A., Anderson, A. K., Silver, R. E., Barger, K., Krauss, A., Karhunen, L., Zhang, X., Hambly, C., Schwab, U., Triffoni-Melo, A. d. T., Fassini, P. G., Taylor, S. F., Economos, C., Kurpad, A. V., & Speakman, J. R. (2018). Measured energy content of frequently purchased restaurant meals: multi-country cross sectional study. *BMJ,* 363. https://doi.org/10.1136/bmj.k4864

Robinson, E., Benwell, H., & Higgs, S. (2013). Food intake norms increase and decrease snack food intake in a remote confederate study. *Appetite, 65*, 20-24. https://doi.org/10.1016/j.appet.2013.01.010

Rolls, B., Morris, E., & Roe, L. (2002). Portion size of food affects energy intake in normal-weight and overweight men and women. *American Journal of Clinical Nutrition, 76*(6), 1207-1213. doi: 10.1093/ajcn/76.6.1207.

Romieu, I., Dossus, L., Barquera, S., Blottiere, H. M., Franks, P. W., Gunter, M., Hwalla, N., Hursting, S. D., Leitzmann, M., Margetts, B., Nishida, C., Potischman, N., Seidell, J., Stepien, M., Wang, Y., Westerterp, K., Winichagoon, P., Wiseman, M., Willett, W. C., Balance, I. w. g. o. E., & Obesity. (2017). Energy balance and obesity: what are the main drivers? *Cancer Causes and Control*, *28*(3), 247-258. https://doi.org/10.1007/s10552-017-0869-z

Rose, D., Bodor, J. N., Hutchinson, P. L., & Swalm, C. M. (2010). The importance of a multi-dimensional approach for studying the links between food access and consumption. *Journal of Nutrition*, *140*(6), 1170-1174. https://doi.org/10.3945/jn.109.113159

Rose, D., Hutchinson, P. L., Bodor, J. N., Swalm, C. M., Farley, T. A., Cohen, D. A., & Rice, J. C. (2009). Neighborhood food environments and Body Mass Index: the importance of in-store contents. *American Journal of Preventive Medicine*, *37*(3), 214-219. https://doi.org/10.1016/j.amepre.2009.04.024

Rundle, A., Neckerman, K. M., Freeman, L., Lovasi, G. S., Purciel, M., Quinn, J., Richards, C., Sircar, N., & Weiss, C. (2009). Neighborhood food environment and walkability predict obesity in New York City. *Environmental Health Perspectives*, *117*(3), 442-447. https://doi.org/10.1289/ehp.11590

Russell, J. (1980). A circumplex model of affect. *Journal of Personality and Social Psychology*, *39*(6), 1161-1178.

Russell, S. J., Croker, H., & Viner, R. M. (2019). The effect of screen advertising on children's dietary intake: A systematic review and meta-analysis. *Obesity Reviews*, *20*(4), 554-568. https://doi.org/10.1111/obr.12812

Saelens, B. E., Gehrman, C. A., Sallis, J. F., Calfas, K. J., Sarkin, J. A., & Caparosa, S. (2000). Use of self-management strategies in a 2-year cognitive-behavioral intervention to promote physical activity. *Behavior Therapy*, *31*(2), 365-379. https://doi.org/10.1016/s0005-7894(00)80020-9

Sallis, J. F. (2010). Temporal Self-Regulation Theory: A step forward in the evolution of health behaviour models. *Health Psychology Review*, *4*(2), 75-78. https://doi.org/10.1080/17437191003681545

Sanchez-Flack, J. C., Anderson, C. A. M., Arredondo, E. M., Belch, G., Martinez, M. E., & Ayala, G. X. (2018). Fruit and Vegetable Intake of US Hispanics by Food Store Type: Findings from NHANES. *Journal of Racial and Ethnic Health Disparities*, *6*(1), 220-229. https://doi.org/10.1007/s40615-018-0517-7

Saper, C., Chou, T., & Elmquist, J. (2002). The need to feed: Homeostatic and hedonic control of eating. *Neuron*, *36*, 199-211. https://doi.org/10.1016/S0896-6273(02)00969-8

Schoeppe, S., Alley, S., Rebar, A. L., Hayman, M., Bray, N. A., Van Lippevelde, W., Gnam, J.-P., Bachert, P., Direito, A., & Vandelanotte, C. (2017). Apps to improve diet, physical activity and sedentary behaviour in children and adolescents: A review of quality, features and behaviour change techniques. *International Journal of Behavioral Nutrition and Physical Activity*, *14*(1). https://doi.org/10.1186/s12966-017-0538-3

Schüz, B., Bower, J., & Ferguson, S. G. (2015). Stimulus control and affect in dietary behaviours. An intensive longitudinal study. *Appetite*, *87*, 310-317. https://doi.org/10.1016/j.appet.2015.01.002

Schüz, B., Papadakis, T., & Ferguson, S. G. (2018). Situation-specific social norms as mediators of social influence on snacking. *Health Psychology*, *37*(2), 153-159. https://doi.org/10.1037/hea0000568

Schüz, B., Revell, S., Hills, A. P., Schüz, N., & Ferguson, S. G. (2017). Higher BMI is associated with stronger effects of social cues on everyday snacking behaviour. *Appetite, 114,* 1-5. https://doi.org/10.1016/j.appet.2017.03.012

Schüz, B., Schüz, N., & Ferguson, S. G. (2015). It's the power of food: Individual differences in food cue responsiveness and snacking in everyday life. *International Journal of Behavioral Nutrition and Physical Activity*, *12*, 149. https://doi.org/10.1186/s12966-015-0312-3

Schüz, N., Walters, J. A., Frandsen, M., Bower, J., & Ferguson, S. G. (2014). Compliance with an EMA monitoring protocol and its relationship with participant and smoking characteristics. *Nicotine & Tobacco Research*, *16 Suppl 2*, S88-92. https://doi.org/10.1093/ntr/ntt142

Seguin, R. A., Aggarwal, A., Vermeylen, F., & Drewnowski, A. (2016). Consumption frequency of foods away from home linked with higher body mass index and lower fruit and vegetable intake among adults: A cross-sectional study. *Journal of Environmental and Public Health*, *2016*, 3074241. https://doi.org/10.1155/2016/3074241

Sellahewa, D. A., & Mullan, B. (2015). Health behaviours and their facilitation under depletion conditions: The case of snacking. *Appetite*, *90*, 194-199. https://doi.org/10.1016/j.appet.2015.03.009

Sherwood, N. E., Crowther, J. H., & Ben-Porath, Y. B. (2000). The perceived function of bulimic, subclinical bulimic, and non-eating disordered women. *Behavior Therapy*, *31*(4), 777-793. https://doi.org/10.1016/S0005-7894(00)80044-1

Shiffman, S. (2009). Ecological momentary assessment (EMA) in studies of substance use. *Psychological Assessment*, *21*(4), 486-497. https://doi.org/10.1037/a0017074

Shiffman, S., Dunbar, M. S., & Ferguson, S. G. (2015). Stimulus control in intermittent and daily smokers. *Psychology of Addictive Behaviors*, *29*(4), 847-855. https://doi.org/10.1037/adb0000052

Shiffman, S., Dunbar, M. S., Li, X., Scholl, S. M., Tindle, H. A., Anderson, S. J., & Ferguson, S. G. (2014). Smoking patterns and stimulus control in intermittent and daily smokers. *PloS One*, *9*(3), e89911. https://doi.org/10.1371/journal.pone.0089911

Shiffman, S., Stone, A., & Hufford, M. (2008). Ecological momentary assessment. *The Annual Review of Clinical Psychology*, *4*, 1-32. https://doi.org/10.1146/annurev.clinpsy.3.022806.091415

Silventoinen, K., Sans, S., Tolonen, H., Monterde, D., Kuulasmaa, K., Kesteloot, H., Tuomilehto, J., & Project, W. M. (2004). Trends in obesity and energy supply in the WHO MONICA Project. *International Journal of Obesity and Related Metabolic Disorders*, *28*(5), 710-718. https://doi.org/10.1038/sj.ijo.0802614

Simons, J. S., & Carey, K. B. (2003). Personal strivings and marijuana use initiation, frequency, and problems. *Addictive Behaviors*, *28*(7), 1311-1322. https://doi.org/10.1016/s0306-4603(02)00247-2

Small, D. M. (2009). Individual differences in the neurophysiology of reward and the obesity epidemic. *International Journal of Obesity (2005)*, *33 Suppl 2*, S44-48. https://doi.org/10.1038/ijo.2009.71

Smith, D., Cummins, S., Clark, C., & Stansfelf, S. (2013). Does the local food environment around schools affect diet? Longitudinal associations in adolescents attending secondary schools in East London. *BMC Public Health*, *13*(70). http://www.biomedcentral.com/articles/10.1186/1471-2458-13-70

Smyth, J. M., Wonderlich, S. A., Heron, K. E., Sliwinski, M. J., Crosby, R. D., Mitchell, J. E., & Engel, S. G. (2007). Daily and momentary mood and stress are associated with binge eating and vomiting in bulimia nervosa patients in the natural environment. *Journal of Consulting and Clinical Psychology*, *75*(4), 629-638. https://doi.org/10.1037/0022-006X.75.4.629

Snijders, T. A. B., & Boskers, R. J. (2012). *Multilevel analysis: An introduction to basic and advanced multilevel modeling* (2nd ed.). Sage, London.

Sobik, L., Hutchison, K., & Craighead, L. (2005). Cue-elicited craving for food: A fresh approach to the study of binge eating. *Appetite*, *44*(3), 253-261. https://doi.org/10.1016/j.appet.2004.12.001

Sominsky, L., & Spencer, S. J. (2014). Eating behavior and stress: A pathway to obesity. *Frontiers in Psychology*, *5*, 434. https://doi.org/10.3389/fpsyg.2014.00434

Spanakis, G., Weiss, G., Boh, B., Lemmens, L., & Roefs, A. (2017). Machine learning techniques in eating behavior e-coaching. *Personal and Ubiquitous Computing*, *21*(4), 645-659. https://doi.org/10.1007/s00779-017-1022-4

Spence, C., Okajima, K., Cheok, A. D., Petit, O., & Michel, C. (2016). Eating with our eyes: From visual hunger to digital satiation. *Brain and Cognition*, *110*, 53-63. https://doi.org/10.1016/j.bandc.2015.08.006

Spook, J. E., Paulussen, T., Kok, G., & Van Empelen, P. (2013). Monitoring dietary intake and physical activity electronically: feasibility, usability, and ecological validity of a mobile-based Ecological Momentary Assessment tool. *Journal of Medical Internet Research*, *15*(9), e214. https://doi.org/10.2196/jmir.2617

Sproesser, G., Schupp, H. T., & Renner, B. (2014). The bright side of stress-induced eating: Eating more when stressed but less when pleased. *Psychological Science*, *25*(1), 58-65. https://doi.org/10.1177/0956797613494849

Stein, R. I., Kenardy, J., Wiseman, C. V., Dounchis, J. Z., Arnow, B. A., & Wilfley, D. E. (2007). What's driving the binge in binge eating disorder?: A prospective examination of precursors and consequences. *International Journal of Eating Disorders*, *40*(3), 195-203. https://doi.org/10.1002/eat.20352

Stok, F. M., De Vet, E., Wardle, J., Chu, M. T., De Wit, J., & De Ridder, D. T. (2015). Navigating the obesogenic environment: How psychological sensitivity to the food environment and self-regulatory competence are associated with adolescent unhealthy snacking. *Eating Behaviors*, *17*, 19-22. https://doi.org/10.1016/j.eatbeh.2014.12.003

Stone, A. A., Broderick, J. E., Schwartz, J. E., Shiffman, S., Litcher-Kelly, L., & Calvanese, P. (2003). Intensive momentary reporting of pain with an electronic diary: Reactivity, compliance, and patient satisfaction. *Pain*, *104*(1), 343-351. https://doi.org/10.1016/s0304-3959(03)00040-x

Story, M., Kaphingst, K. M., Robinson-O'Brien, R., & Glanz, K. (2008). Creating healthy food and eating environments: Policy and environmental approaches. *Annual Review of Public Health*, *29*, 253-272. https://doi.org/10.1146/annurev.publhealth.29.020907.090926

Stroebe, W. (2002). Übergewicht als Schicksal? Die kognitive Steuerung des Essverhaltens [Obesity as fate? Cognitive regulation of eating]. *Psychologische Rundschau*, *53*, 14-22.

Stroebe, W., Mensink, W., Aarts, H., Schut, H., & Kruglanski, A. W. (2008). Why dieters fail: Testing the goal conflict model of eating. *Journal of Experimental Social Psychology*, *44*(1), 26-36. https://doi.org/10.1016/j.jesp.2007.01.005

Stroebe, W., Papies, E. K., & Aarts, H. (2008). From Homeostatic to Hedonic Theories of Eating: Self-Regulatory Failure in Food-Rich Environments. *Applied Psychology*, *57*(s1), 172-193. https://doi.org/10.1111/j.1464-0597.2008.00360.x

Stroebe, W., van Koningsbruggen, G. M., Papies, E. K., & Aarts, H. (2013). Why most dieters fail but some succeed: A goal conflict model of eating behavior. *Psychology Reviews, 120*(1), 110-138. https://doi.org/10.1037/a0030849

Sullivan, H. W., & Rothman, A. J. (2008). When planning is needed: Implementation intentions and attainment of approach versus avoidance health goals. *Health Psychology*, *27*(4), 438-444. https://doi.org/10.1037/0278-6133.27.4.438

Swinburn, B., & Egger, G. (2002). Preventive strategies against weight gain and obesity. *Obesity Reviews, 3*(4), 289-301. https://doi.org/10.1046/j.1467-789X.2002.00082.x

Swinburn, B. A., Sacks, G., Hall, K. D., McPherson, K., Finegood, D. T., Moodie, M. L., & Gortmaker, S. L. (2011). The global obesity pandemic: Shaped by global drivers and local environments. *The Lancet*, *378*(9793), 804-814. https://doi.org/10.1016/s0140-6736(11)60813-1

Tangney, J. P., Baumeister, R. F., & Boone, A. (2004). High self-control predicts good adjustment, less pathology, better grades, and interpersonal success. *Journal of Personality*, *72*(2), 271-324. https://doi.org/10.1111/j.0022-3506.2004.00263.x

Teixeira, P. J., Carraca, E. V., Marques, M. M., Rutter, H., Oppert, J. M., De Bourdeaudhuij, I., Lakerveld, J., & Brug, J. (2015). Successful behavior change in obesity interventions in adults: A systematic review of self-regulation mediators. *BMC Medicine*, *13,* 84. https://doi.org/10.1186/s12916-015-0323-6

Thomas, J. G., Doshi, S., Crosby, R. D., & Lowe, M. R. (2011). Ecological Momentary Assessment of obesogenic eating behavior: Combining person-specific and environmental predictors. *Obesity (Silver Spring)*, *19*(8), 1574-1579. https://doi.org/10.1038/oby.2010.335

Thornton, L. E., Cameron, A. J., McNaughton, S. A., Worsley, A., & Crawford, D. A. (2012). The availability of snack food displays that may trigger impulse purchases in Melbourne supermarkets. *BMC Public Health*, *12*, 194. https://doi.org/10.1186/1471-2458-12-194

Thornton, L. E., Crawford, D. A., Lamb, K. E., & Ball, K. (2017). Where do people purchase food? A novel approach to investigating food purchasing locations. *International Journal of Health Geographics*, *16*(9). https://doi.org/10.1186/s12942-017-0082-z

Thornton, L. E., & Kavanagh, A. M. (2012). Association between fast food purchasing and the local food environment. *Nutrition & Diabetes*, *2*, e53. https://doi.org/10.1038/nutd.2012.27

Thornton, L. E., Lamb, K. E., & Ball, K. (2016). Fast food restaurant locations according to socioeconomic disadvantage, urban-regional locality, and schools within Victoria, Australia. *SSM Population Health*, *2*, 1-9. https://doi.org/10.1016/j.ssmph.2015.12.001

Tiwari, A., Aggarwal, A., Tang, W., & Drewnowski, A. (2017). Cooking at Home: A Strategy to Comply With U.S. Dietary Guidelines at No Extra Cost. *American Journal of Preventive Medicine*, *52*(5), 616-624. https://doi.org/10.1016/j.amepre.2017.01.017

Todd, J., & Mullan, B. (2014). The role of self-monitoring and response inhibition in improving sleep behaviours. *International Journal of Behavioral Medicine*, *21*(3), 470-477. https://doi.org/10.1007/s12529-013-9328-8

Trapp, G. S., Hickling, S., Christian, H. E., Bull, F., Timperio, A. F., Boruff, B., Shrestha, D., & Giles-Corti, B. (2015). Individual, social, and environmental correlates of healthy and unhealthy eating. *Health Education and Behavior*, *42*(6), 759-768. https://doi.org/10.1177/1090198115578750

Tsai, A. G., & Wadden, T. A. (2005). Systematic review: An evaluation of major commercial weight loss programs in the United States. *Annals of Internal*

Medicine, *142*(1), 56-66. https://doi.org/10.7326/0003-4819-142-1-200501040-00012

Turbutt, C., Richardson, J., & Pettinger, C. (2018). The impact of hot food takeaways near schools in the UK on childhood obesity: A systematic review of the evidence. *Journal of Public Health (Oxford Academic)*, *41*(2), 231-239. https://doi.org/10.1093/pubmed/fdy048

van Koningsbruggen, G. M., Stroebe, W., Papies, E. K., & Aarts, H. (2011). Implementation intentions as goal primes: Boosting self-control in tempting environments. *European Journal of Social Psychology*, *41*(5), 551-557. https://doi.org/10.1002/ejsp.799

VanDeMark, N. R. (2007). Policy on reintegration of women with histories of substance abuse: a mixed methods study of predictors of relapse and facilitators of recovery. *Substance Abuse Treatment, Prevention and Policy*, *2*, 28. https://doi.org/10.1186/1747-597X-2-28

Vartanian, L. R., Herman, C. P., & Wansink, B. (2008). Are we aware of the external factors that influence our food intake? *Health Psychology*, *27*(5), 533-538. https://doi.org/10.1037/0278-6133.27.5.533

Vartanian, L. R., Spanos, S., Herman, C. P., & Polivy, J. (2017). Conflicting internal and external eating cues: Impact on food intake and attributes. *Journal of Health Psychology*, *26*(4), 365-369. doi: 10.1037/hea0000447

Verhoeven, A. A., Adriaanse, M. A., Evers, C., & de Ridder, D. T. (2012). The power of habits: Unhealthy snacking behaviour is primarily predicted by habit strength. *British Journal of Health Psychology*, *17*(4), 758-770. https://doi.org/10.1111/j.2044-8287.2012.02070.x

Wagner, H. S., Ahlstrom, B., Redden, J. P., Vickers, Z., & Mann, T. (2014). The myth of comfort food. *Health Psychology*, *33*(12), 1552-1557. https://doi.org/10.1037/hea0000068

Wahl, D. R., Villinger, K., Blumenschein, M., Konig, L. M., Ziesemer, K., Sproesser, G., Schupp, H. T., & Renner, B. (2020). Why we eat what we eat: Assessing dispositional and in-the-moment eating motives by using Ecological Momentary Assessment. *JMIR Mhealth Uhealth*, *8*(1), e13191. https://doi.org/10.2196/13191

Wahl, D. R., Villinger, K., König, L. M., Ziesemer, K., Schupp, H. T., & Renner, B. (2017). Healthy food choices are happy food choices: Evidence from a real life sample using smartphone based assessments. *Scientific Reports*, *7*(1). https://doi.org/10.1038/s41598-017-17262-9

Wansink, B., Payne, C. R., & Shimizu, M. (2010). "Is this a meal or snack?" Situational cues that drive perceptions. *Appetite*, *54*(1), 214-216. https://doi.org/10.1016/j.appet.2009.09.016

Watson, P., Wiers, R. W., Hommel, B., Ridderinkhof, K. R., & de Wit, S. (2016). An associative account of how the obesogenic environment biases adolescents' food choices. *Appetite*, *96*, 560-571. https://doi.org/10.1016/j.appet.2015.10.008

Watson, W. L., Kury, A., Wellard, L., Hughes, C., Dunford, E., & Chapman, K. (2016). Variations in serving sizes of Australian snack foods and confectionery. *Appetite*, *96*, 32-37. https://doi.org/10.1016/j.appet.2015.08.042

Webb, T. L., Joseph, J., Yardley, L., & Michie, S. (2010). Using the internet to promote health behavior change: a systematic review and meta-analysis of the impact of theoretical basis, use of behavior change techniques, and mode of delivery on efficacy. *Journal of Medical Internet Research*, *12*(1), e4. https://doi.org/10.2196/jmir.1376

Weingarten, H. P. (1985). Stimulus control of eating: Implications for a two-factor theory of hunger. *Appetite*, *6*(4), 387-401. https://doi.org/10.1016/s0195-6663(85)80006-4

Wellard, L., Havill, M., Hughes, C., Watson, W. L., & Chapman, K. (2015). The availability and accessibility of nutrition information in fast food outlets in five states post-menu labelling legislation in New South Wales. *Australian and New Zealand Journal of Public Health*, *39*(6), 546-549. https://doi.org/10.1111/1753-6405.12428

West, J. H., Blumberg, E. J., Kelley, N. J., Hill, L., Sipan, C. L., Schmitz, K. E., Ryan, S., Clapp, J. D., & Hovell, M. F. (2010). Does proximity to retailers influence alcohol and tobacco use among Latino adolescents? *Journal of Immigrant and Minority Health*, *12*(5), 626-633. https://doi.org/10.1007/s10903-009-9303-2

Wheeler, L., & Reis, H. T. (1991). Self-Recording of Everyday Life Events: Origins, Types, and Uses. *Journal of Personality*, *59*(3), 339-354. https://doi.org/10.1111/j.1467-6494.1991.tb00252.x

Whittaker, R., McRobbie, H., Bullen, C., Rodgers, A., & Gu, Y. (2016). Mobile phone-based interventions for smoking cessation. *Cochrane Database of Systematic Reviews*, *4*, CD006611. https://doi.org/10.1002/14651858.CD006611.pub4

WHO. (2016). *Obesity and overweight*. World Health Organization. Retrieved November 4, 2016 from http://www.who.int/mediacentre/factsheets/fs311/en/

WHO. (2019). *Body Mass Index- BMI*. World Health Organization. Retrieved June 6, 2019 from http://www.euro.who.int/en/health-topics/disease-prevention/nutrition/a-healthy-lifestyle/body-mass-index-bmi

Widener, M. J., Minaker, L., Farber, S., Allen, J., Vitali, B., Coleman, P. C., & Cook, B. (2017). How do changes in the daily food and transportation environments affect grocery store accessibility? *Applied Geography*, *83*, 46-62. https://doi.org/10.1016/j.apgeog.2017.03.018

Wilding, S., Conner, M., Sandberg, T., Prestwich, A., Lawton, R., Wood, C., Miles, E., Godin, G., & Sheeran, P. (2016). The question-behaviour effect: A theoretical and methodological review and meta-analysis. *European Review of Social Psychology*, *27*(1), 196-230. https://doi.org/10.1080/10463283.2016.1245940

Wing, R. (2004). Behavioural approaches to the treatment of obesity. In G. Bray & C. Bouchard (Eds.), *Handbook of obesity, clinical applications* (pp. 147-162). Marcel Dekker, New York.

Witt, A. A., Raggio, G. A., Butryn, M. L., & Lowe, M. R. (2014). Do hunger and exposure to food affect scores on a measure of hedonic hunger? An experimental study. *Appetite*, *74*, 1-5. https://doi.org/10.1016/j.appet.2013.11.010

Wouters, S., Jacobs, N., Duif, M., Lechner, L., & Thewissen, V. (2017). Affect and between-meal snacking in daily life: the moderating role of gender and age. *Psychology & Health*, 33(4), 1-18. https://doi.org/10.1080/08870446.2017.1380813

Zellner, D. A., Loaiza, S., Gonzalez, Z., Pita, J., Morales, J., Pecora, D., & Wolf, A. (2006). Food selection changes under stress. *Physiology and Behavior*, *87*(4), 789-793. https://doi.org/10.1016/j.physbeh.2006.01.014

Zenk, S. N., Horoi, I., McDonald, A., Corte, C., Riley, B., & Odoms-Young, A. M. (2014). Ecological Momentary Assessment of environmental and personal factors and snack food intake in African American women. *Appetite*, *83*, 333-341. https://doi.org/10.1016/j.appet.2014.09.008

Zenk, S. N., Lachance, L. L., Schulz, A. J., Mentz, G., Kannan, S., & Ridella, W. (2009). Neighborhood retail food environment and fruit and vegetable intake in a multiethnic urban population. *American Journal of Health Promotion*, *23*(4), 255-264. https://doi.org/10.4278/ajhp.071204127

Zenk, S. N., Schulz, A. J., Matthews, S. A., Odoms-Young, A., Wilbur, J., Wegrzyn, L., Gibbs, K., Braunschweig, C., & Stokes, C. (2011). Activity space environment and dietary and physical activity behaviors: A pilot study. *Health Place*, *17*(5), 1150-1161. https://doi.org/10.1016/j.healthplace.2011.05.001

Zhang, R., Wulff, H., Duan, Y., & Wagner, P. (2018). Associations between the physical environment and park-based physical activity: A systematic review. *Journal of Sport and Health Science, 8*(5), 412-421. https://doi.org/10.1016/j.jshs.2018.11.002

Zhao, J., Freeman, B., & Li, M. (2016). Can Mobile Phone Apps Influence People's Health Behavior Change? An Evidence Review. *Journal of Medical Internet Research*, *18*(11), e287. https://doi.org/10.2196/jmir.5692

Zizza, C., Siega-Riz, A. M., & Popkin, B. M. (2001). Significant increase in young adults' snacking between 1977-1978 and 1994-1996 represents a cause for concern! *Preventive Medicine*, *32*(4), 303-310. https://doi.org/10.1006/pmed.2000.0817

Appendices

Appendix 1.1. Published version of Paper 1: Chapter 23 Ambulatory Assessment

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Appendix 2.1. Chapter 2 (Study 1): Abstract presented at the European Health Psychology conference 2018

Daily goal conflict and adherence to dieting goals: An ecological momentary assessment study

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Background: Reducing discretionary food intake— "snacking"— is an integral part of dieting. However, individuals may experience difficulties in reducing their snacking due to self-regulatory problems arising from conflicts between dieting and other personal goals. Here, we examine the impact of goal conflict on snacking during two weeks of dieting.

Method: At baseline, 94 dieters completed an assessment of goals using Little's personal project analysis. Participants identified 7 goals; one of which was pre-defined as adhering to diet. Over the beginning 14 days of their diet, participants recorded their food in real-time using an electronic diary. Every evening, participants reported the goals they had engaged in and which goals conflicted or facilitated with their dieting goal.

Findings: Over the study duration, 1251 days of food intake and goal conflict were recorded. Participants consumed an average of 1.4 (*SD*= 0.8) daily snacks. 72.3% of people experienced at least one day of goal conflict. On 15.7% of days participants experienced at least one conflicting goal with their dieting goal. The number of snacks did not differ between days when conflict with the dieting goal was experienced and days without goal conflict. The likelihood of experiencing conflict with the dieting goal did not change over the study.

Discussion: Examining the day-to-day changes in goal conflict is an important step in understanding how individuals prioritise and manage their goals. This study suggests that the impact of goal conflict on dieting may not be via snacking behaviour. Implications for theories that include goal conflict will be discussed.

Appendix 2.2. Chapter 2 (Study 1): EMA questionnaire

Questionnaire: Wakeup Report

Q#	Type of Data	Text	Response type	Response options	Notes/skip patterns
1	Question	Good Morning! How long ago did you wake up?	Push Button (pick one)	1. <15 mins, 2. 15 - 30 mins 3. 30 - 60 mins 4. >60 mins	
	Instruction	The following questions refer to events occurring since the last morning report:			
2	Question	Have you consumed any meals but NOT yet entered? If yes, how many?	Spinner	0-10+	
3	Question	Have you consumed any snacks but NOT yet entered? If yes, how many?	Spinner	0-10+	
4	Question	Have you consumed any drinks but NOT yet entered? If yes, how many?	Spinner	0-10+	
5	Question	Do you currently crave food?	Slider	0-100 (with No!!-Yes!! anchors)	

Main Menu: Food Log

Q#	Type of Data	Text	Response type	Response options	Notes/skip patterns
0	GPS				GPS location of participants at time of log start
0	Photo				Participants take photograph of their food

1	Question	What type of food?	Push Button (pick all that apply)	1. Fruit and vegetable 2. Starchy Foods 3. Fish 4. Red Meat 5. Poultry 6. Cheese 7. Sweets or Chocolate 8. Cake, Scone, Sweet Pies, Danish 9. Biscuits 10. Ice Cream 11. Crisps, Savoury Snacks	
2	Question	Consumed a drink with your meal?	Push Button (pick one)	1. Yes 2. No	
3	Question	What type of drink	Check Box (all that apply)	Coffee Tea Milk Alcohol Energy drink Normal soft drink/fizzy drink Calorie-reduced soft drink/fizzy drink Juice Water Other	Ask only if Q2= yes
4	Question	How many drinks in last 15 minutes?	Spinner	1-5+	Ask only if Q3= drinking alcohol
5	Question	Do you feel intoxicated/drunk?	Slider	0-100 (with No!!-Yes!! anchors)	Ask only if Q3= drinking alcohol

	Instruction	Remaining items refer to the situation where you first decided to eat		
	Header	FEELING:		
6	Question	Alert?	Slider	0-100 (with No!!-Yes!! anchors)
7	Question	Angry/frustrated?	Slider	0-100 (with No!!-Yes!! anchors)
8	Question	Bored?	Slider	0-100 (with No!!-Yes!! anchors)
9	Question	Calm/relaxed?	Slider	0-100 (with No!!-Yes!! anchors)
10	Question	Able to focus?	Slider	0-100 (with No!!-Yes!! anchors)
11	Question	Happy?	Slider	0-100 (with No!!-Yes!! anchors)
12	Question	Irritable?	Slider	0-100 (with No!!-Yes!! anchors)
13	Question	Stressed?	Slider	0-100 (with No!!-Yes!! anchors)
14	Question	Restless?	Slider	0-100 (with No!!-Yes!! anchors)
15	Question	Sad?	Slider	0-100 (with No!!-Yes!! anchors)
16	Question	Energy level?	Push Button (pick one)	1.Very low 2. Low 3. Moderate 4. High 5. Very high
17	Question	Overall feeling?	Push Button (pick one)	1. Very bad 2. Bad 3. Neutral 4. Good 5. Very good
	Header	WHEN YOU DECIDED TO EAT:		

18	Question	Location?	Push Button (pick one)	1.Home 2. Workplace 3. Other's home 4. Bar 5. Restaurant 6. Vehicle 7. Outside 8. Between Places 9. Other	
19	Question	Food available?	Check Box (all that apply, but see note)	None Confectionary Savoury Dairy Biscuits/cakes/pastries Fast food Other	Don’t allow no + any other option
20	Question	From where you are NOW, can you walk in 5 min or see…	Check Box (all that apply)	Franchised Fast Food Other Fast Food Sit-down Restaurant Supermarket Smaller food Shop Convenience Store Specialty Food Shop Chemist or Bargain Shop	
21	Question	With others?	Check Box (all that apply, but see note)	Alone Friends Acquaintances Family members Co-workers Romantic partner	Don't allow alone + any other option

22	Question	People eating?	Check Box (all that apply, but see note)	No In my group, In view	Don’t allow no + any other option
23	Question	Activities?	Check Box (all that apply)	Working/chores Inactive/leisure Interacting with others Between activities Other activities	
24	Question	Type of work?	Push Button (pick one)	1. Job, School 2. House/Personal 3. Other	Ask only if Q23= working/chores
25	Question	Type of inactivity/leisure?	Push Button (pick one)	1. Media 2. Hanging out 3. Hobbies 4. Sports/Exercise 5. Reading 6. Waiting 7. Doing nothing 8. Other	Ask only if Q23= inactivity/leisure
26	Question	Type of interaction with others?	Push Button (pick one)	1. Socializing 2. For business 3. Household issues 4. Arguing 5. Other interaction	Ask only if Q23= interacting with others
27	Question	Is it socially acceptable to eat right now?	Slider	0-100 (with No!!-Yes!! anchors)	
28	Question	Do you think the people with you would approve of eating right now?	Slider	0-100 (with No!!-Yes!! anchors)	Don’t ask if Q21= alone

29	Question	Have the people with you right now encouraged you to eat?	Slider	0-100 (with No!!-Yes!! anchors)	Don’t ask if Q21= alone
30	Question	From where you are now, what food or beverage-related advertisements can you see?	Push Button (pick all that apply but see note)	1. None 2. Media advertisements a. TV b. Radio c. Social media 3. Poster advertisements a. Billboards b. Other outdoor signs 4. Advertisements on vehicles a. Food vans b. Trucks c. Cars d. Buses 5. Other	Show options with numbers, and then expand a,b,c etc. if option selected. Don't allow none + any other option

Main Menu: Drink log

Q#	**Type of Data**	**Text**	**Response type**	**Response options**	**Notes/skip patterns**
0	GPS				GPS location of participant at log start
1	Question	Drink	Push Button (pick one)	1.Coffee 2. Tea 3. Milk 4. Alcohol 5. Energy drink 6. Normal soft drink/fizzy drink 7. Calorie-reduced soft drink/fizzy drink	*Only proceed to rest of questions if report drink with high energy content (i.e. if report caffeine/alcohol/energy drink)

				8. Juice 9. Water 10. Other	
	Header	ABOUT THIS DRINK EPISODE:			
2	Question	How many standard drinks?	Spinner	0-10+	Ask only if Q1= alcohol
3	Question	Intoxicated/drunk?	Slider	0-100 (with No!!-Yes!! anchors)	Ask only if Q1= alcohol
	Instruction	Remaining items refer to the situation where you first decided to drink			
	Header	FEELING:			
4	Question	Alert?	Slider	0-100 (with No!!-Yes!! anchors)	
5	Question	Angry/frustrated?	Slider	0-100 (with No!!-Yes!! anchors)	
6	Question	Bored?	Slider	0-100 (with No!!-Yes!! anchors)	
7	Question	Calm/relaxed?	Slider	0-100 (with No!!-Yes!! anchors)	
8	Question	Able to focus?	Slider	0-100 (with No!!-Yes!! anchors)	
9	Question	Happy?	Slider	0-100 (with No!!-Yes!! anchors)	
10	Question	Irritable?	Slider	0-100 (with No!!-Yes!! anchors)	
11	Question	Stressed?	Slider	0-100 (with No!!-Yes!! anchors)	
12	Question	Restless?	Slider	0-100 (with No!!-Yes!! anchors)	
13	Question	Sad?	Slider	0-100 (with No!!-Yes!! anchors)	
14	Question	Energy level?	Push Button (pick one)	1. Very low 2. Low 3. Moderate 4. High 5. Very high	
15	Question	Overall feeling?	Push Button (pick one)	1.Very bad 2. Bad 3. Neutral	

				4. Good 5. Very good	
	Header	WHEN YOU DECIDED TO DRINK:			
16	Question	Location?	Push Button (pick one)	1. Home 2. Workplace 3. Other's home 4. Bar 5. Restaurant 6. Vehicle 7. Outside 8. Other	
17	Question	Food available?	Check Box (all that apply, but see note)	None Confectionary Savoury Dairy Biscuits/cakes/pastries Fast food Other	Don't allow none + any other option
18	Question	From where you are NOW, can you walk in 5 min or see…	Check Box (all that apply)	Franchised Fast Food Other Fast Food Sit-down Restaurant Supermarket Smaller food Shop Convenience Store Specialty Food Shop Chemist or Bargain Shop	
19	Question	With others?	Check Box (all that apply, but see note)	Alone Friends Acquaintances Family members	Don't allow alone + any other option

				Co-workers Romantic partner	
20	Question	People drinking?	Check Box (all that apply, but see note)	No In my group In view	Don’t allow no + any other option
21	Question	Activities?	Check Box (all that apply)	Working/chores Inactive/leisure Interacting with others Between activities Other activities	
22	Question	Type of work?	Push Button (pick one)	1. Job 2. School 3. House/Personal 4. Other	Ask only if Q21= working/chores
23	Question	Type of inactivity/leisure?	Push Button (pick one)	1. Media 2. Hanging out 3. Hobbies 4. Sports/Exercise 5. Reading 6. Waiting 7. Doing nothing 8. Other	Ask only if Q21= inactivity/leisure
24	Question	Type of interaction with others?	Push Button (pick one)	1. Socializing 2. For business 3. Household issues 4. Arguing 5. Other interaction	Ask only if Q21= interacting with others
25	Question	Is it socially acceptable to drink right now?	Slider	0-100 (with No!!-Yes!! anchors)	

26	Question	Do you think the people with you would approve of drinking right now?	Slider	0-100 (with No!!-Yes!! anchors)	Don't ask if Q19= alone
27	Question	Have the people with you right now encouraged you to drink?	Slider	0-100 (with No!!-Yes!! anchors)	Don't ask if Q19= alone
28	Question	From where you are now, what food or beverage-related advertisements can you see?	Push Button (pick all that apply but see note)	1. None 2. Media advertisements a. TV b. Radio c. Social media 3. Poster advertisements a. Billboards b. Other outdoor signs 4. Advertisements on vehicles a. Food vans b. Trucks c. Cars d. Buses 5. Other	Show options with numbers, and then expand a,b,c etc. if option selected. Don't allow none + any other option

Questionnaire: Random Prompts

Q#	**Type of Data**	**Text**	**Response type**	**Response options**	**Notes/skip patterns**
	Instruction	ABOUT YOUR LAST FOOD/DRINK:			
1	Question	How long ago did the event occur?	Push Button (pick one)	1. 0-10 mins 2. 10-30mins 3. 30-60 mins 4. 1-2hours 5. 2-3 hours	

				6. >3hours
2	Question	Was the food/drink satisfying?	Slider	0-100 (with No!!-Yes!! anchors)
3	Question	Was the food/drink enjoyable/pleasing?	Slider	0-100 (with No!!-Yes!! anchors)
4	Question	How much did you consume?	Push Button (pick one)	1. More than usual 2. Same as usual 3. Less than usual
	Header	RIGHT NOW:		
5	Question	Alert?	Slider	0-100 (with No!!-Yes!! anchors)
6	Question	Angry/frustrated?	Slider	0-100 (with No!!-Yes!! anchors)
7	Question	Bored?	Slider	0-100 (with No!!-Yes!! anchors)
8	Question	Calm/relaxed?	Slider	0-100 (with No!!-Yes!! anchors)
9	Question	Able to focus?	Slider	0-100 (with No!!-Yes!! anchors)
10	Question	Happy?	Slider	0-100 (with No!!-Yes!! anchors)
11	Question	Irritable?	Slider	0-100 (with No!!-Yes!! anchors)
12	Question	Stressed?	Slider	0-100 (with No!!-Yes!! anchors)

13	Question	Restless?	Slider	0-100 (with No!!-Yes!! anchors)
14	Question	Sad?	Slider	0-100 (with No!!-Yes!! anchors)
15	Question	Energy level?	Push Button (pick one)	1. Very low 2. Low 3. Moderate 4. High 5. Very high
16	Question	Overall feeling?	Push Button (pick one)	1. Very bad 2. Bad 3. Neutral 4. Good 5. Very good
	Header	RIGHT NOW:		
17	Question	Location?	Push Button (pick one)	1. Home 2. Workplace 3. Other's home 4. Bar 5. Restaurant 6. Vehicle 7. Outside 8. Other
18	Question	From where you are NOW, can you walk in 5 min or see…	Check Box (all that apply, but see note)	Franchised Fast Food Other Fast Food Sit-down Restaurant Smaller food Shop Convenience Store Specialty Food Shop Chemist or Bargain Shop

19	Question	Food available?	Check Box (all that apply, but see note)	No Candy Bar Chocolate Other confectionary Chips Cheese Cracker Fruit/Nuts Dairy Biscuits/cakes/pastries Fast food Other	Don’t allow no + any other option
20	Question	With others?	Check Box (all that apply, but see note)	Alone Friends Acquaintances Family members Co-workers Romantic partner	Don't allow alone + any other option
21	Question	People eating?	Check Box (all that apply, but see note)	No In my group In view	Don’t allow no + any other option
22	Question	Activities?	Check Box (all that apply)	Working/chores Inactive/leisure Interacting with others Between activities Other activities	
23	Question	Type of work?	Push Button (pick one)	1. Job 2. School 3. House/Personal 4. Other	Ask only if Q22= working/chores

24	Question	Type of inactivity/leisure?	Push Button (pick one)	1. Media 2. Hanging out 3. Hobbies 4. Sports/Exercise 5. Reading 6. Waiting 7. Doing nothing 8. Other	Ask only if Q22= inactivity/leisure
25	Question	Type of interaction with others?	Push Button (pick one)	1. Socializing 2. For business 3. Household issues 4. Arguing 5. Other interaction	Ask only if Q22= interacting with others
26	Question	Would you like to eat right now but think that you shouldn't?	Slider	0-100 (with No!!-Yes!! anchors)	
25	Question	Is it socially acceptable to eat or drink right now?	Slider	0-100 (with No!!-Yes!! anchors)	
26	Question	Do you think the people with you would approve of eating or drinking right now?	Slider	0-100 (with No!!-Yes!! anchors)	Don’t ask if Q20= alone
27	Question	Have the people with you right now encouraged you to eat or drink?	Slider	0-100 (with No!!-Yes!! anchors)	Don’t ask if Q20= alone

28	Question	From where you are now, what food or beverage-related advertisements can you see?	Push Button (pick all that apply but see note)	1. None 2. Media advertisements a. TV b. Radio c. Social media 3. Poster advertisements a. Billboards b. Other outdoor signs 4. Advertisements on vehicles a. Food vans b. Trucks c. Cars d. Buses 5. Other	Show options with numbers, and then expand a,b,c etc. if option selected. Don't allow none + any other option

Questionnaire: Evening Report

Q#	Type of Data	Text	Response type	Response options	Notes/skip patterns
	Instruction	The following questions refer to events occurring since the last morning report:			
1	Question	How many meals consumed today?	Spinner	0-10+	
2	Question	How many snacks consumed today?	Spinner	0-10+	
3	Question	How many drinks consumed today?	Spinner	0-10+	
4	Question	Found yourself craving food at any stage?	Slider	0-100 (with No!!-Yes!! anchors)	If yes, go to Q5 then Q6 If no, skip to question 7
5	Question	Was the craving intense?	Slider	0-100 (with No!!-Yes!! anchors)	

6	Question	What type of food were you craving?	Push Button (pick one)	1. Candy Bar 2. Chocolate 3. Other Confectionary 4. Chips 5. Cheese 6. Cracker 7. Fruit/Nuts 8. Dairy 9. Biscuits/cakes/pastries 10. Fast food 11. Other
7	Question	Overall feeling	Push Button (pick one)	1. Very bad 2. Bad 3. Neutral 4. Good 5. Very good
8	Question	Energy level?	Slider	0-100 (with No!!-Yes!! anchors)
9	Question	Able to control important things?	Slider	0-100 (with No!!-Yes!! anchors)
10	Question	Able to handle personal problems?	Slider	0-100 (with No!!-Yes!! anchors)
11	Question	Nervous / stressed?	Slider	0-100 (with No!!-Yes!! anchors)
12	Question	Things going your way?	Slider	0-100 (with No!!-Yes!! anchors)
13	Question	Unexpected things upset you?	Slider	0-100 (with No!!-Yes!! anchors)
14	Question	Upset by things outside of your control?	Slider	0-100 (with No!!-Yes!! anchors)
15	Question	Meals consumed but NOT yet entered?	Spinner	0-5+
16	Question	Snacks consumed but NOT yet entered?	Spinner	0-10+
17	Question	Drinks consumed but NOT yet entered?	Spinner	0-10+
18	Question	Felt like eating but didn’t'?	Slider	0-100 (with No!!-Yes!! anchors)

19	Question	Exercised today?	Push Button (pick one)	1. No 2. Yes	
20	Question	How long did you exercise for?	Push Button (pick one)	1. 0-10mins 2. 10-30mins 3. 30mins-1hour 4. 1-2hours 5. 2-3 hours 6. >3hours	*ask only if Q19= yes
	Instruction	The following questions refer to each episode (activity) you have done today and what goals were involved.			
	Instruction	Refer to your personal projects list for the number corresponding with your goals			
21	Question	6-9am: Goals involved?	Push Button (pick several)	Goal 1 Goal 2 Goal 3 Goal 4 Goal 5 Goal 6 Goal 7	*repeat for each time period (9-12noon, 12-3pm, 3-6pm).
22		6-9am: Goal conflict?	Push Button (pick several)	*response options will include only the goals participants identified in Q21	*repeat for each time period (9-12noon, 12-3pm, 3-6pm).
23		6-9am: Goal facilitation?	Push Button (pick several)	*response options will include only the goals participants identified in Q21	*repeat for each time period (9-12noon, 12-3pm, 3-6pm).

Appendix 2.3. Chapter 2 (Study 1): Baseline questionnaire

Q#	Question	Response options
1	Gender	Male Female
2	What is your ethnicity/ancestry?	Caucasian/European Aboriginal Torres Strait Islander Other *(Please choose all that apply)*
3	What is the highest level of education that you have completed?	Year 10 or less Year 12 (or equivalent) Some university Graduated university Graduated TAFE No answer
4	What diet are you attempting?	*(Enter text)*
5	What is the reason you are dieting?	To lose weight To maintain weight Other
6	Do you do your own cooking/meal preparation at home?	*(Choose one of the following answers)* Rarely or none of the time Some of the time (1-2 days a week) Much of the time (3-4 days a week) Most of the time (5-7 days a week)
7	How often do you 'eat out' (e.g., at a restaurant/café, etc.)?	*(Choose one of the following answers)* Rarely or none of the time Some of the time (1-2 days a week) Much of the time (3-4 days a week) Most of the time (5-7 days a week)
8	How often do you eat 'take away' or 'fast food' (e.g., McDonalds, Hungry Jacks, Subway)?	*(Choose one of the following answers)* Rarely or none of the time

		Some of the time (1-2 days a week) Much of the time (3-4 days a week) Most of the time (5-7 days a week)
Please select the option from the following statement that best describes you		
9	When I am doing well at something I love to keep at it	Very true for me Somewhat true for me Somewhat false for me Very false for me
10	When I get something I want, I feel excited and energised	Very true for me Somewhat true for me Somewhat false for me Very false for me
11	When I see an opportunity for something I like I get excited right away	Very true for me Somewhat true for me Somewhat false for me Very false for me
12	When good things happen to me, it affects me strongly	Very true for me Somewhat true for me Somewhat false for me Very false for me
13	I feel worried when I think I have done poorly at something important	Very true for me Somewhat true for me Somewhat false for me Very false for me
14	It would excite me to win a contest	Very true for me Somewhat true for me Somewhat false for me Very false for me
For each of the following statements, please indicate if you felt this way during the past week		
15	I was bothered by things that usually don't bother me	Rarely or none of the time (less than 1 day)

		Some of the time (1-2 days a week)
		Much of the time (3-4 days a week)
		Most of the time (5-7 days a week)
		Rarely or none of the time (less than 1 day)
		Some of the time (1-2 days a week)
		Much of the time (3-4 days a week)
16	I had trouble keeping my mind on what I was doing	Most of the time (5-7 days a week
		Rarely or none of the time (less than 1 day)
		Some of the time (1-2 days a week)
		Much of the time (3-4 days a week)
17	I felt depressed	Most of the time (5-7 days a week
		Rarely or none of the time (less than 1 day)
		Some of the time (1-2 days a week)
		Much of the time (3-4 days a week)
18	I felt that everything I did was an effort	Most of the time (5-7 days a week
		Rarely or none of the time (less than 1 day)
		Some of the time (1-2 days a week)
		Much of the time (3-4 days a week)
19	My sleep was restless	Most of the time (5-7 days a week
		Rarely or none of the time (less than 1 day)
		Some of the time (1-2 days a week)
		Much of the time (3-4 days a week)
20	I was happy	Most of the time (5-7 days a week
		Rarely or none of the time (less than 1 day)
		Some of the time (1-2 days a week)
		Much of the time (3-4 days a week)
21	I felt lonely	Most of the time (5-7 days a week
		Rarely or none of the time (less than 1 day)
		Some of the time (1-2 days a week)
22	I felt hopeful about the future	Much of the time (3-4 days a week)

		Most of the time (5-7 days a week
		Rarely or none of the time (less than 1 day)
		Some of the time (1-2 days a week)
		Much of the time (3-4 days a week)
23	I felt fearful	Most of the time (5-7 days a week
		Rarely or none of the time (less than 1 day)
		Some of the time (1-2 days a week)
		Much of the time (3-4 days a week)
24	I could not get going	Most of the time (5-7 days a week

Please indicate how much you agree with the following statements

		I don’t agree
		I agree a little
		I agree somewhat
	I find myself thinking about food even when I am not physically	I agree quite a bit
25	hungry	I strongly agree
		I don’t agree
		I agree a little
		I agree somewhat
	I get more pleasure from eating than I do from almost anything	I agree quite a bit
26	else	I strongly agree
		I don’t agree
		I agree a little
		I agree somewhat
		I agree quite a bit
27	If I see or smell a food I like, I get a powerful urge to have some	I strongly agree
		I don’t agree
		I agree a little
		I agree somewhat
	When I’m around a fattening food I love, it’s hard to stop myself	I agree quite a bit
28	from at least tasting it	I strongly agree

29	It’s scary to think of the power that food has over me	I don’t agree I agree a little I agree somewhat I agree quite a bit I strongly agree
30	When I know a delicious food is available, it’s hard to stop myself from thinking about having some	I don’t agree I agree a little I agree somewhat I agree quite a bit I strongly agree
31	I love the taste of certain foods so much that I can’t avoid eating them, even if they’re bad for me	I don’t agree I agree a little I agree somewhat I agree quite a bit I strongly agree
32	Just before I taste a favourite food, I feel intense anticipation	I don’t agree I agree a little I agree somewhat I agree quite a bit I strongly agree

Please indicate the extent to which you agree that the following items describe you

33	When I eat a delicious food, I focus a lot on how food it tastes	I don’t agree I agree a little I agree somewhat I agree quite a bit I strongly agree
34	Sometimes, when I’m doing everyday activities, I get an urge to et “out of the blue” (for no apparent reason)	I don’t agree I agree a little I agree somewhat I agree quite a bit

		I strongly agree
		I don’t agree
		I agree a little
		I agree somewhat
		I agree quite a bit
35	I think I enjoy eating a lot more than most other people	I strongly agree
		I don’t agree
		I agree a little
		I agree somewhat
		I agree quite a bit
36	Hearing someone describe a great meal makes me really want to have something to eat	I strongly agree
		I don’t agree
		I agree a little
		I agree somewhat
		I agree quite a bit
37	It seems like I have food on my mind a lot	I strongly agree
		I don’t agree
		I agree a little
		I agree somewhat
		I agree quite a bit
38	It is very important to me that the foods I eat are as delicious as possible	I strongly agree
		I don’t agree
		I agree a little
		I agree somewhat
		I agree quite a bit
39	Before I eat a favourite food, my mouth tends to fill with saliva	I strongly agree

The next questions ask about your eating habits in the past year. People sometimes have difficulty controlling their intake of certain foods such as:
-Sweets like ice cream, chocolate, donuts, cookies, cake, candy;
-Starches like white bread, rolls, pasta and rice;
-Salty snacks like chips, pretzels and crackers;

-Fatty foods like steak, bacon, hamburgers, cheeseburgers, pizza and French fries;
-Sugary drinks like soft drinks, red bull.
When the following questions ask about 'certain foods', please think of ANY foods similar to those listed above, or any other foods you have had a problem with in the past year

40	I find that when I start eating certain foods, I end up eating much more than planned	Never Once a month 2-4 times a month 2-3 times a week 4 or more times a week, or daily
41	I find myself continuing to consume certain foods, even when I am no longer hungry	Never Once a month 2-4 times a month 2-3 times a week 4 or more times a week, or daily
42	I eat to the point where I feel physically ill	Never Once a month 2-4 times a month 2-3 times a week 4 or more times a week, or daily
43	Not eating certain types of food, or cutting down on certain types of food, is something that I worry about	Never Once a month 2-4 times a month 2-3 times a week 4 or more times a week, or daily
44	I spend a lot of time feeling sluggish or fatigued from overeating	Never Once a month 2-4 times a month 2-3 times a week 4 or more times a week, or daily
45	I find myself constantly eating certain foods throughout the day	Never

		Once a month 2-4 times a month 2-3 times a week 4 or more times a week, or daily
46	I find that when certain foods are not available, I will go out of my way to obtain them. For example, I will drive to the store to purchase certain foods, even though I have other options available to me at home	Never Once a month 2-4 times a month 2-3 times a week 4 or more times a week, or daily
47	There have been times when I’ve consumed certain foods so often or in large quantities, that I started to eat food instead of working, spending time with my family or friends, or engaging in other important activities that I enjoy	Never Once a month 2-4 times a month 2-3 times a week 4 or more times a week, or daily
48	There have been times when I’ve avoided professional or social situations where certain foods are available, because I was afraid I would overeat	Never Once a month 2-4 times a month 2-3 times a week 4 or more times a week, or daily
49	There have been times when I’ve avoided professional or social situations because I was not about to consume certain foods there	Never Once a month 2-4 times a month 2-3 times a week 4 or more times a week, or daily
50	I have had withdrawal symptoms such as agitation, or other physical symptoms when I cut down or stopped eating certain foods (please do not include withdrawal symptoms caused by cutting down caffeinated beverages such as soft drink, coffee, tea, energy drinks etc.)	Never Once a month 2-4 times a month 2-3 times a week 4 or more times a week, or daily

51	I have found that I have elevated desire for or urges to consume certain foods when I cut down or stop eating them	Never Once a month 2-4 times a month 2-3 times a week 4 or more times a week, or daily
52	My behaviour with respect to food and eating causes me significant distress	Never Once a month 2-4 times a month 2-3 times a week 4 or more times a week, or daily
53	I experience significant problems in my ability to function effectively (daily routine, job, school, social activities, family activities, health difficulties) because of food and eating	Never Once a month 2-4 times a month 2-3 times a week 4 or more times a week, or daily
Please select the option from the following scale that best describes how often you have felt/behaved this way in the last 12 months		
54	My food consumption has caused significant psychological problems such as depression, self-loathing, anxiety, or guilt	No Yes
55	My food consumption has caused significant physical problems or made a physical problem worse	No Yes
56	I kept consuming the same types of food or the same amount of food even though I was having emotional and/or physical problems	No Yes
57	Over time, I have found that I need to eat more and more to get the feeling I want, such as reduced negative emotions, or increased pleasure	No Yes
58	I have found that eating the same amount of food does not reduce my negative emotions or increase pleasurable feelings the way it used to	No Yes
59	I want to cut down or stop eating certain kinds of food	No Yes

Please select the option from the following scale that best describes how often you have felt/behaved in this way in the last 12 months

60	How many times in the past year did you try to cut down or stop eating certain foods altogether?	None One time Two times Three times Four times Five or more times

The next two questions relate to healthy food choices- this means choosing, for example, a low calorie option (e.g., an apple) over a high-calorie option (e.g., a chocolate bar) when you decide to have a meal or snack. Imagine yourself in that situation, and think about the outcomes of your food choice

61	If you were to experience costs from making a healthy food choice, when do you think you would notice them?	When I am thinking about whether or not to make a healthy food choice When I make the decision to make a healthy food choice While I am getting ready to make a healthy food choice While I am making a healthy food choice After making a healthy food choice once After making healthy food choices regularly for a week After making healthy food choices regularly for a year After making healthy food choices regularly for several years After making healthy food choices regularly for several decades
62	If you were to experience benefits from making a healthy food choice, when do you think you would notice them?	When I am thinking about whether or not to make a healthy food choice When I make the decision to make a healthy food choice While I am getting ready to make a healthy food choice While I am making a healthy food choice After making a healthy food choice once After making healthy food choices regularly for a week After making healthy food choices regularly for a year After making healthy food choices regularly for several years After making healthy food choices regularly for several decades

The next questions are about whether you have intentions or plans to change your diet in the future

63	I intend to make more healthy food choices	Strongly disagree Disagree

		Neither agree not disagree Agree Strongly agree
64	I am confident that I could make more healthy food choices even if it was difficult	Strongly disagree Disagree Neither agree not disagree Agree Strongly agree
65	I have made a detailed plan on when, where and how to implement more healthy food choices	Strongly disagree Disagree Neither agree not disagree Agree Strongly agree
66	I have made a detailed plan on how to make healthy food choices even if something gets in the way	Strongly disagree Disagree Neither agree not disagree Agree Strongly agree

The next questions are about yourself. Using the scale provided, please indicate how much each of the following statements reflects how you typically are

67	I am good at resisting temptation	1- Not at all 2 3 4 5- Very much
68	I have a hard time breaking bad habits	1- Not at all 2 3 4 5- Very much

69	I am lazy	1- Not at all 2 3 4 5- Very much
70	I say inappropriate things	1- Not at all 2 3 4 5- Very much
71	I do certain things that are bad for me if they are fun	1- Not at all 2 3 4 5- Very much
72	I refuse things that are bad for me	1- Not at all 2 3 4 5- Very much
73	I wish I had more self-discipline	1- Not at all 2 3 4 5- Very much
74	People would say that I have iron self-discipline	1- Not at all 2 3 4 5- Very much

75	Pleasure and fun sometimes keep me from getting work done	1- Not at all 2 3 4 5- Very much
76	I have trouble concentrating	1- Not at all 2 3 4 5- Very much
77	I am able to work effectively towards long-term goals	1- Not at all 2 3 4 5- Very much
78	Sometimes I can’t stop myself from doing something, even if I know it is wrong	1- Not at all 2 3 4 5- Very much
79	I often act without thinking through all the alternatives	1- Not at all 2 3 4 5- Very much

The next questions are about how you typically deal with tasks

80	I can concentrate on one activity for a long time if necessary	Not at all true Barely true Somewhat true Completely true

81	When I am distracted from an activity, I don't have any problem coming back to the topic quickly	Not at all true Barely true Somewhat true Completely true
82	If an activity arouses my feelings too much, I can calm myself down so that I can continue with the activity soon	Not at all true Barely true Somewhat true Completely true
83	If an activity requires a problem-oriented attitude, I can control my feelings	Not at all true Barely true Somewhat true Completely true
84	It is difficult for me to suppress thoughts that interfere with what I need to do	Not at all true Barely true Somewhat true Completely true
85	I can control my thoughts from distracting me from the task at hand	Not at all true Barely true Somewhat true Completely true
86	When I worry about something, I cannot concentrate on an activity	Not at all true Barely true Somewhat true Completely true
87	After an interruption, I don't have any problem resuming my concentrated style of working	Not at all true Barely true Somewhat true Completely true
88	I usually have a whole bunch of thoughts and feelings that interfere with my ability to work in a focused way	Not at all true Barely true

Somewhat true
Completely true
Not at all true
Barely true
Somewhat true
Completely true

89	I stay focused on my goal and don't allow anything to distract me from my plan of action	Not at all true Barely true Somewhat true Completely true

Most health organisations suggest that a healthy diet is one that consists of at least five portions (servings of fruit and vegetables) per day

90	On how many days during the last week have you eaten at least five portions (servings) of fruit and vegetables	0 out of 7 1 out of 7 2 out of 7 3 out of 7 4 out of 7 5 out of 7 6 out of 7 7 out of 7

We are interested in studying the kinds of activities and concerns that people have over the course of their lives. We call these personal projects. All of us have a number of personal projects at any given time that we think about, plan for, carry out and sometimes (though not always) complete.

Some projects may be focused on achievement ("Getting my degree") others on the process ("Enjoying a night out with friends"); they may be things we choose to do or things we have to do; they may be things we are working towards or things we are trying to avoid. Projects may be related to any aspect of your daily life, university, work, home, leisure and community, among others. Please think of projects in this broad way.

To start, please take 5-10 minutes and write down on the following page(s) six personal projects and activities you can that you are currently engaged in or considering -- remember these need not be formal projects or even important ones -- we would prefer you to give us more of the everyday kinds of activities or concerns that characterize your life at present.

91		*Enter text* Project 1: Adhering to diet Project 2: Project 3: Project 4:

		Project 5: Project 6: Project 7: If you would like to list additional projects and activities, please list them here.
92	How important is adhering to diet [project 1]?	0-100 scale (0= not at all, 100= extremely)
93	How much do you feel you are in control of adhering to diet [project 1]?	0-100 scale (0= not at all, 100= extremely)
94	All of us have things that we do that we feel are typical or true expressions of ourselves. These things can be thought of as our 'trade marks'. For example, some people engage in sports every chance they get, others prefer to read, others prefer to socialise. Think of what your own personal 'trade marks' are, and then rate [project 1] on the extent to which it is typical of you.	0-100 scale (0= not at all, 100= extremely)
95	How important is adhering to diet [project 2]?	0-100 scale (0= not at all, 100= extremely)
96	How much do you feel you are in control of [project 2]?	0-100 scale (0= not at all, 100= extremely)
97	All of us have things that we do that we feel are typical or true expressions of ourselves. These things can be thought of as our 'trade marks'. For example, some people engage in sports every chance they get, others prefer to read, others prefer to socialise. Think of what your own personal 'trade marks' are, and then rate [project 2] on the extent to which it is typical of you.	0-100 scale (0= not at all, 100= extremely)
98	How important is adhering to diet [project 3]?	0-100 scale (0= not at all, 100= extremely)
99	How much do you feel you are in control of [project 3]?	0-100 scale (0= not at all, 100= extremely)
100	All of us have things that we do that we feel are typical or true expressions of ourselves. These things can be thought of as our 'trade marks'. For example, some people engage in sports every chance they get, others prefer to read, others prefer to socialise. Think of what your own personal 'trade marks' are, and then rate [project 3] on the extent to which it is typical of you.	0-100 scale (0= not at all, 100= extremely)

101	How important is adhering to diet [project 4]?	0-100 scale (0= not at all, 100= extremely)
102	How much do you feel you are in control of [project 4]?	0-100 scale (0= not at all, 100= extremely)
103	All of us have things that we do that we feel are typical or true expressions of ourselves. These things can be thought of as our ‘trade marks’. For example, some people engage in sports every chance they get, others prefer to read, others prefer to socialise. Think of what your own personal ‘trade marks’ are, and then rate [project 4] on the extent to which it is typical of you.	0-100 scale (0= not at all, 100= extremely)
104	How important is adhering to diet [project 5]?	0-100 scale (0= not at all, 100= extremely)
105	How much do you feel you are in control of [project 5]?	0-100 scale (0= not at all, 100= extremely)
106	All of us have things that we do that we feel are typical or true expressions of ourselves. These things can be thought of as our ‘trade marks’. For example, some people engage in sports every chance they get, others prefer to read, others prefer to socialise. Think of what your own personal ‘trade marks’ are, and then rate [project 5] on the extent to which it is typical of you.	0-100 scale (0= not at all, 100= extremely)
107	How important is adhering to diet [project 6]?	0-100 scale (0= not at all, 100= extremely)
108	How much do you feel you are in control of [project 6]?	0-100 scale (0= not at all, 100= extremely)
109	All of us have things that we do that we feel are typical or true expressions of ourselves. These things can be thought of as our ‘trade marks’. For example, some people engage in sports every chance they get, others prefer to read, others prefer to socialise. Think of what your own personal ‘trade marks’ are, and then rate [project 6] on the extent to which it is typical of you.	0-100 scale (0= not at all, 100= extremely)
110	How important is adhering to diet [project 7]?	0-100 scale (0= not at all, 100= extremely)
111	How much do you feel you are in control of [project 7]?	0-100 scale (0= not at all, 100= extremely)
112	All of us have things that we do that we feel are typical or true expressions of ourselves. These things can be thought of as our ‘trade marks’. For example, some people engage in sports every chance they get, others prefer to read, others prefer to socialise.	0-100 scale (0= not at all, 100= extremely)

	Think of what your own personal ‘trade marks’ are, and then rate [project 7] on the extent to which it is typical of you.	
113	How much do [project 1] and [project 2] affect each other?	0-100 scale (0= not at all, 100= extremely)
114	How much do [project 1] and [project 3] affect each other?	0-100 scale (0= not at all, 100= extremely)
115	How much do [project 1] and [project 4] affect each other?	0-100 scale (0= not at all, 100= extremely)
116	How much do [project 1] and [project 5] affect each other?	0-100 scale (0= not at all, 100= extremely)
117	How much do [project 1] and [project 6] affect each other?	0-100 scale (0= not at all, 100= extremely)
118	How much do [project 1] and [project 7] affect each other?	0-100 scale (0= not at all, 100= extremely)
119	How much do [project 2] and [project 3] affect each other?	0-100 scale (0= not at all, 100= extremely)
120	How much do [project 2] and [project 4] affect each other?	0-100 scale (0= not at all, 100= extremely)
121	How much do [project 2] and [project 5] affect each other?	0-100 scale (0= not at all, 100= extremely)
122	How much do [project 2] and [project 6] affect each other?	0-100 scale (0= not at all, 100= extremely)
123	How much do [project 2] and [project 7] affect each other?	0-100 scale (0= not at all, 100= extremely)
124	How much do [project 3] and [project 4] affect each other?	0-100 scale (0= not at all, 100= extremely)
125	How much do [project 3] and [project 5] affect each other?	0-100 scale (0= not at all, 100= extremely)
126	How much do [project 3] and [project 6] affect each other?	0-100 scale (0= not at all, 100= extremely)
127	How much do [project 3] and [project 7] affect each other?	0-100 scale (0= not at all, 100= extremely)
128	How much do [project 4] and [project 5] affect each other?	0-100 scale (0= not at all, 100= extremely)
129	How much do [project 4] and [project 6] affect each other?	0-100 scale (0= not at all, 100= extremely)
130	How much do [project 4] and [project 7] affect each other?	0-100 scale (0= not at all, 100= extremely)
131	How much do [project 5] and [project 6] affect each other?	0-100 scale (0= not at all, 100= extremely)
132	How much do [project 5] and [project 7] affect each other?	0-100 scale (0= not at all, 100= extremely)
133	How much do [project 6] and [project 7] affect each other?	0-100 scale (0= not at all, 100= extremely)

Appendix 5.1. Chapter 5 (Study 4): Abstract presented at the European Health Psychology conference 2018

Examining the association between food outlets and eating behaviour: A Geographic Information System (GIS) study

Katherine Elliston and Stuart Ferguson

University of Tasmania, Australia

Background: mHealth apps can deliver content to individuals as they go about their daily lives. In addition, researchers are interested in using mHealth apps to predict behaviours before they occur and proactively intervene. Discretionary food intake—“snacking”— has been shown to be influenced by environmental food cues. However, studies that have explored this relationship typically rely on self-reports of environmental cues. Here we explore the feasibility of using geographic information system (GIS) data to predict snacking.

Method: 112 individuals recorded their food intake for two weeks using electronic diaries. Participants also answered questions during other, randomly-timed points throughout the day. During both the eating and randomly-timed (non-eating) assessments, participants reported the type and number of nearby food outlets; additionally, participants diaries recorded their GPS location. GPS location was plotted on a GIS map of food outlets, allowing us to calculate the number (and type) of food outlets within a given radius during each assessment.

Expected results: Objective and self-report data will be compared to determine the correlation between GPS-derived and self-reported location. Next, both estimates will be used in participant-level logistic regression models to determine whether or not location can discriminate between eating and non-eating instances.

Current stage of work: 112 participants worth of data has been collected, with additional data collection and analysis in progress.

Discussion: If passively knowing an individual's location is sufficient to predict eating, then mHealth apps may be able to issue personalised dietary interventions when individuals enter locations where they are at risk of overeating.

Appendix 5.2. Chapter 5 (Study 4): Abstract presented at the European Health Psychology conference 2019

Objective (GIS) and subjective food environment as predictors of momentary food intake

Katherine G. Elliston[1], Stuart G. Ferguson[1] and Benjamin Schüz[2]

[1] College of Health and Medicine, University of Tasmania, Australia

[2] Institute of Public Health and Nursing Science, University of Bremen, Germany

Background: The presence and availability of food has been shown to influence eating. Knowing the presence of food in the environment may enable mHealth apps to determine the most appropriate time to issue interventions. To date, studies on eating often rely on self-reports of environmental context, which may not be feasible for mHealth interventions. Here, we explore the feasibility of using Geographic Information System (GIS) data to predict eating behaviour in order to inform geo-fenced interventions.

Method: 72 participants recorded their food intake in real-time over 14 days using Ecological Momentary Assessment. Participants logged their food intake and responded to ~5 randomly-timed assessments each day. During each assessment, participants reported the number and type of food outlets nearby. Their electronic diaries simultaneously recorded their GPS coordinates. GPS data was later overlayed with a GIS map of food outlets to produce an objective count of the number of food outlets within 50m of the participant.

Findings: Self-reported and GIS counts of food outlets were poorly correlated (r= .17, p<.001). Logistic regression analyses revealed that although GIS counts significantly predict eating, they were similar to the self-reported counts (AUC-ROC self-report= 0.53, SE= 0.00 vs. AUC-ROC GIS= 0.53, SE= 0.00, p= .54). Both counts performed worse than self-reported *type* of food outlet nearby (AUC-ROC= 0.56, p<.001).

Discussion: Subjective food environment predicted eating better than objectively measured food environment via GIS. mHealth apps may need to consider the type of food outlets, rather than the raw number of outlets in an individual's environment.

Appendix 5.3. Chapter 5 (Study 4): EMA questionnaire

Questionnaire: Morning Report

Q#	Type of Data	Text	Response type	Response options	Notes/skip patterns
1	Question	Good Morning! How long ago did you wake up?	1. <15 mins 2. 15-30 mins 3. 30-60 mins 4. >60 mins		
	Header	RIGHT NOW FEELING:			
2	Question	Hungry?	Slider	0-100 (with No!!- Yes!! Anchors)	

Main Menu: Food Log

Q#	Type of Data	Text	Response type	Response options	Notes/skip patterns
0	GPS				GPS location of participants at time of log start
0	Photo				Participants take photograph of their food
1	Question	Type of meal?	Push Button (pick one)	1. Main meal 2. Other	

2	Question	What type of food?	Push Button (pick one)	1. Confectionary 2. Savoury 3. Fruit/vegetables/nuts 4. Dairy 5. Biscuits/cakes/pastries 6. Fast food 7. Other	Ask only if Q1= other
3	Question	Consumed a drink with your meal?	Push Button (pick one)	1. Yes 2. No	
4	Question	What type of drink?	Check Box (all that apply)	Coffee/tea Milk Alcohol Energy drink Normal soft drink Calorie-reduced soft drink Juice Water Other	Ask only if Q3= yes
	Instruction	Remaining items refer to the situation where you first decided to eat			
	Header	FEELING:			
5	Question	Good?	Likert scale 1-5 (pick one response)	Responses: 1 (not at all) to 5(extremely)	

6	Question	Bad?	Likert scale 1-5 (pick one response)	Responses: 1 (not at all) to 5(extremely)
7	Question	Awake?	Likert scale 1-5 (pick one response)	Responses: 1 (not at all) to 5(extremely)
8	Question	Tired?	Likert scale 1-5 (pick one response)	Responses: 1 (not at all) to 5(extremely)
9	Question	Nervous?	Likert scale 1-5 (pick one response)	Responses: 1 (not at all) to 5(extremely)
10	Question	Calm?	Likert scale 1-5 (pick one response)	Responses: 1 (not at all) to 5(extremely)
11	Question	Hungry?	Slider	0-100 (with No!!- Yes!! Anchors)
	Header	WHEN YOU DECIDED TO EAT:		
12	Question	Location?	Push Button (pick one)	1. Home 2. Workplace 3. Other's home 4. Bar 5. Restaurant 6. Vehicle 7. Outside 8. Between places 9. Other

13	Question	From where you are NOW, how many food outlets can you see?	Push +/- button to Indicate number (range: 0 to 5+)	1. Fast food/ take-away stores 2. Restaurants/ cafes 4. Supermarket/ corner store 5. Specialty food stores 6. Discount stores 7. Other	
14	Question	Food available?	Check Box (all that apply, but see note)	None Confectionary Savoury Dairy Biscuits/cakes/pastries Fast food Other	Don’t allow none + any other option
15	Question	With others?	Check Box (all that apply, but see note)	Alone Friends Acquaintances Family members Co-workers Romantic partner	Don't allow alone + any other option
16	Question	People eating/drinking?	Check Box (all that apply, but see note)	No In my group In view	Don’t allow no + any other option
17	Question	Activities?	Push Button (pick one)	1. Working/chores 2. Inactive/leisure 3. Interacting with others 4. Between activities 5. Other activities	

18	Question	Type of interaction with others?	Push Button (pick one)	1. Socialising 2. For business 3. Household issues 4. Arguing 5. Other interaction	Ask only if Q17= interacting with others
19	Question	Do you think the public/people in general would think it's acceptable to eat right now?	Slider	0-100 (with not acceptable-acceptable anchors)	
20	Question	Do you think the people with you would approve or disapprove of you eating right now?	Push Button (pick one)	1. Strongly disapprove 2. Disapprove 3. Neither approve or disapprove 4. Approve 5. Strongly approve	Don't ask if Q15= alone
21	Question	From where you are now, what food or beverage-related advertisements can you see?	Push Button (pick all that apply but see note)	1. None 2. Media advertisements a. TV b. Radio c. Social media 3. Poster advertisements a. Billboards b. Other outdoor signs 4. Advertisements on vehicles a. Food vans b. Trucks c. Cars d. Buses 5. Other	Show options with numbers, and then expand a,b,c etc. if option selected. Don't allow none + any other option

Main Menu: Drink log

Q#	Type of Data	Text	Response type	Response options	Notes/skip patterns
0	GPS				GPS location of participant at log start
1	Question	What type of drink?	Check Box (all that apply)	Coffee/Tea Milk Alcohol Energy drink Normal soft drink Calorie-reduced soft drink Juice Water Other	
	Header	ABOUT THIS DRINK EPISODE:			
2	Question	How many standard drinks?	Spinner	0-10+	Ask only if Q1= alcohol
3	Question	Feeling intoxicated/drunk?	Slider	0-100 (with No!!-Yes!! anchors)	Ask only if Q1= alcohol
	Instruction	Remaining items refer to the situation where you first decided to drink			
	Header	FEELING:			
4	Question	Good?	Likert scale 1-5 (pick one response)	Responses: 1 (not at all) to 5(extremely)	
5	Question	Bad?	Likert scale 1-5 (pick one response)	Responses: 1 (not at all) to 5(extremely)	

6	Question	Awake?	Likert scale 1-5 (pick one response)	Responses: 1 (not at all) to 5(extremely)
7	Question	Tired?	Likert scale 1-5 (pick one response)	Responses: 1 (not at all) to 5(extremely)
8	Question	Nervous?	Likert scale 1-5 (pick one response)	Responses: 1 (not at all) to 5(extremely)
9	Question	Calm?	Likert scale 1-5 (pick one response)	Responses: 1 (not at all) to 5(extremely)
10	Question	Hungry?	Slider	0-100 (with No!!- Yes!! Anchors)
	Header	WHEN YOU DECIDED TO DRINK:		
11	Question	Location?	Push Button (pick one)	1. Home 2. Workplace 3. Other's home 4. Bar 5. Restaurant 6. Vehicle 7. Outside 8. Between places 9. Other

12	Question	From where you are NOW, how many food outlets can you see?	Push +/- button to Indicate number (range: 0 to 5+)	1. Fast food/ take-away stores 2. Restaurants/ cafes 4. Supermarket/ corner store 5. Specialty food stores 6. Discount stores 7. Other	
13	Question	Food available?	Check Box (all that apply, but see note)	None, Confectionary Savoury Dairy Biscuits/cakes/pastries Fast food Other	Don't allow none + any other option
14	Question	With others?	Check Box (all that apply, but see note)	Alone Friends Acquaintances Family members Co-workers Romantic partner	Don't allow alone + any other option
15	Question	People eating/drinking?	Check Box (all that apply, but see note)	No In my group In view	Don't allow no + any other option
16	Question	Activities?	Push Button (pick one)	1. Working/chores 2. Inactive/leisure 3. Interacting with others 4. Between activities 5. Other activities	

17	Question	Type of interaction with others?	Push Button (pick one)	1. Socialising 2. For business 3. Household issues 4. Arguing 5. Other interaction	Ask only if Q16= interacting with others
18	Question	Do you think the public/people in general would think it's acceptable to drink (alcohol) right now?	Slider	0-100 (with not acceptable-acceptable anchors)	
19	Question	Do you think the people with you would approve or disapprove of you drinking (alcohol) right now?	Push Button (pick one)	1. Strongly disapprove 2. Disapprove 3. Neither approve or disapprove 4. Approve 5. Strongly approve	Don't ask if Q14= alone
20	Question	Have the people with you right now encouraged you to drink (alcohol)?	Slider	0-100 (with No!!-Yes!! anchors)	Don't ask if Q14= alone

21	Question	From where you are now, what food or beverage-related advertisements can you see?	Push Button (pick all that apply but see note)	1. None 2. Media advertisements a. TV b. Radio c. Social media 3. Poster advertisements a. Billboards b. Other outdoor signs 4. Advertisements on vehicles a. Food vans b. Trucks c. Cars d. Buses 5. Other	Show options with numbers, and then expand a,b,c etc. if option selected. Don't allow none + any other option

Questionnaire: Random Prompts

Q#	Type of Data	Text	Response type	Response options	Notes/skip patterns
0	GPS				GPS location of participants at time of log start
	Instruction	ABOUT YOUR LAST FOOD/DRINK:			
1	Question	Was your last food/drink satisfying?	Slider	0-100 (with No!!-Yes!! anchors)	

2	Question	How much did you consume?	Push Button (pick one)	1. More than usual 2. Same as usual 3. Less than usual
	Header	RIGHT NOW FEELING:		
3	Question	Good?	Likert scale 1-5 (pick one response)	Responses: 1 (not at all) to 5(extremely)
4	Question	Bad?	Likert scale 1-5 (pick one response)	Responses: 1 (not at all) to 5(extremely)
5	Question	Awake?	Likert scale 1-5 (pick one response)	Responses: 1 (not at all) to 5(extremely)
6	Question	Tired?	Likert scale 1-5 (pick one response)	Responses: 1 (not at all) to 5(extremely)
7	Question	Nervous?	Likert scale 1-5 (pick one response)	Responses: 1 (not at all) to 5(extremely)
8	Question	Calm?	Likert scale 1-5 (pick one response)	Responses: 1 (not at all) to 5(extremely)
9	Question	Hungry?	Slider	0-100 (with No!!- Yes!! Anchors)
	Header	RIGHT NOW:		

10	Question	Location?	Push Button (pick one)	1. Home 2. Workplace 3. Other's home 4. Bar 5. Restaurant 6. Vehicle 7. Outside 8. Between places 9. Other	
11	Question	From where you are NOW, how many food outlets can you see?	Push +/- button to Indicate number (range: 0 to 5+)	1. Fast food/ take-away stores 2. Restaurants/ cafes 4. Supermarket/ corner store 5. Specialty food stores 6. Discount stores 7. Other	
12	Question	Food available?	Check Box (all that apply, but see note)	None Confectionary Savoury Dairy Biscuits/cakes/pastries Fast food Other	Don’t allow none + any other option
13	Question	With others?	Check Box (all that apply, but see note)	Alone Friends Acquaintances Family members Co-workers Romantic partner	Don't allow alone + any other option

14	Question	People eating/drinking?	Check Box (all that apply, but see note)	No In my group In view	Don’t allow no + any other option
15	Question	Activities?	Push Button (pick one)	1. Working/chores 2. Inactive/leisure 3. Interacting with others 4. Between activities 5. Other activities	
16	Question	Type of interaction with others?	Push Button (pick one)	1. Socialising 2. For business 3. Household issues 4. Arguing 5. Other interaction	Ask only if Q15= interacting with others
17	Question	Are you craving any food?	Push Button (pick one)	1. No 2. Yes	
18	Question	What food are you craving?	Check Box (all that apply)	Candy bar/chocolate Other confectionary Chips Cheese Cracker Fruit/nuts Dairy Biscuits/cakes/pastries Fast food Other	Ask only if Q17= yes

19	Question	Do you think the public/people in general would think it's acceptable to eat right now?	Slider	0-100 (with not acceptable-acceptable anchors)	
20	Question	Do you think the public/people in general would think it's acceptable to drink (alcohol) right now?	Slider	0-100 (with not acceptable-acceptable anchors)	
21	Question	Do you think the people with you would approve or disapprove of you eating right now?	Push Button (pick one)	1. Strongly disapprove 2. Disapprove 3. Neither approve or disapprove 4. Approve 5. Strongly approve	Don't ask if Q13= alone
22	Question	Do you think the people with you would approve or disapprove of you drinking (alcohol) right now?	Push Button (pick one)	1. Strongly disapprove 2. Disapprove 3. Neither approve or disapprove 4. Approve 5. Strongly approve	Don't ask if Q13= alone

23	Question	From where you are now, what food or beverage-related advertisements can you see?	Push Button (pick all that apply but see note)	1. None 2. Media advertisements a. TV b. Radio c. Social media 3. Poster advertisements a. Billboards b. Other outdoor signs 4. Advertisements on vehicles a. Food vans b. Trucks c. Cars d. Buses 5. Other	Show options with numbers, and then expand a,b,c etc. if option selected. Don't allow none + any other option

Questionnaire: Evening Report

Q#	Type of Data	Text	Response type	Response options	Notes/skip patterns
	Instruction	The following questions refer to events occurring since the last morning report:			
1	Question	How many meals consumed today?	Spinner	0-10+	
2	Question	How many snacks consumed today?	Spinner	0-10+	
3	Question	How many drinks consumed today?	Spinner	0-10+	
4	Question	Found yourself craving food at any stage?	Push Button (pick one)	1. Yes 2. No	
5	Question	Was the craving intense?	Slider	0-100 (with No!!-Yes!! anchors)	Ask only if answer Q4= yes

6	Question	What type of food were you craving?	Check Box (all that apply)	Candy bar/chocolate Other confectionary Chips Cheese Cracker Fruit/nuts Dairy Biscuits/cakes/pastries Fast food Other	Ask only if Q4= yes
	Header	OVERALL FEELING TODAY:			
7	Question	Good?	Likert scale 1-5 (pick one response)	Responses: 1 (not at all) to 5(extremely)	
8	Question	Bad?	Likert scale 1-5 (pick one response)	Responses: 1 (not at all) to 5(extremely)	
9	Question	Awake?	Likert scale 1-5 (pick one response)	Responses: 1 (not at all) to 5(extremely)	
10	Question	Tired?	Likert scale 1-5 (pick one response)	Responses: 1 (not at all) to 5(extremely)	
11	Question	Nervous?	Likert scale 1-5 (pick one response)	Responses: 1 (not at all) to 5(extremely)	
12	Question	Calm?	Likert scale 1-5 (pick one response)	Responses: 1 (not at all) to 5(extremely)	

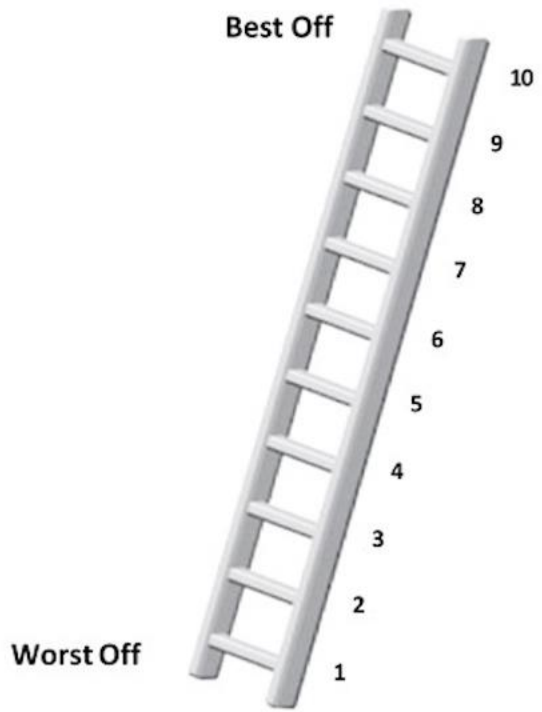
13	Question	Stressed?	Likert scale 1-5 (pick one response)	Responses: 1 (not at all) to 5(extremely)	
14	Question	Meals consumed but not yet entered?	Spinner	0-10+	
15	Question	Snacks consumed but not yet entered?	Spinner	0-10+	
16	Question	Drinks consumed but not yet entered?	Spinner	0-10+	
17	Question	Exercised today?	Push Button (pick one)	1. Yes 2. No	
18	Question	How long did you exercise for?	Push Button (pick one)	1. 0-10mins 2. 10-30mins 3. 30mins-1hr 4. 1-2hrs 5. 2-3hrs 6. >3hrs	Ask only if Q14=yes

Appendix 5.4. Chapter 5 (Study 4): Baseline questionnaire

Q#	Question	Response options
1	Gender	Male Female
2	What is your ethnicity/ancestry?	Caucasian/European Aboriginal Torres Strait Islander Asian Other *(Please choose all that apply)*
3	What is the highest level of education that you have completed?	Year 10 or less Year 12 (or equivalent) Some university Graduated university Graduated TAFE No answer
4	Are you currently employed? *Note: if the 'yes' box is selected, participants will be directed to question 5 (asking about their current occupation), if not, they will be directed straight to question 6 (assessment income)*	Yes No I'm a student I'm retired *(Please choose all that apply)*
5	How would you describe your current occupation?	Manager Professional Technician and trade worker Community and personal service worker Clerical and administrative worker Sales worker Machinery operators and drivers Labourer
6	What is your income?	*Weekly personal income (annual)* Negative income

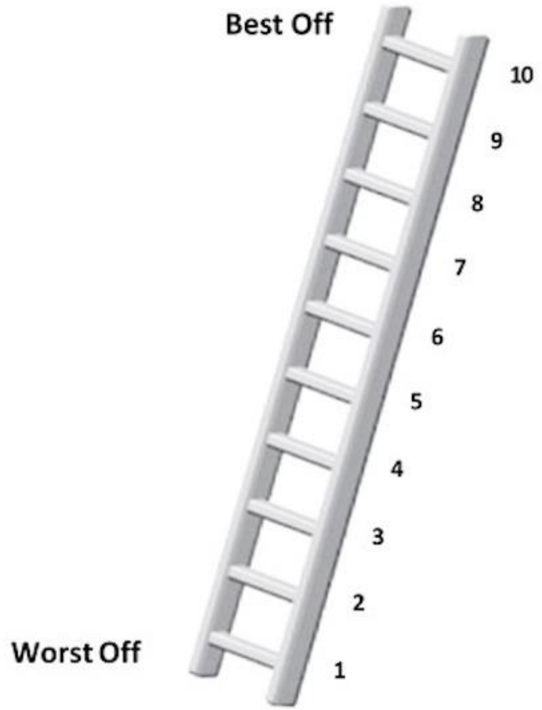
Nil income
$1-$149 ($1-$7,799)
$150-$299 ($7,800-$15,599)
$300-$399 ($15,600-$20,799)
$400-$499 ($20,800-$25,999)
$500-$649 ($26,000-$33,799)
$650-$799 ($33,800-$41,599)
$800-$999 ($41,600-$51,999)
$1,000-$1,249 ($52,000-$64,999)
$1,250-$1,499 ($65,000-$77,999)
$1,500-$1,749 ($78,000-$90,999)
$1,750-$1,999 ($91,000-$103,999)
$2,000-$2,999 ($104,000-$155,999)
$3,000 or more ($156,000 or more)

Think of this ladder as representing where people stand in their communities.
People define community in different ways; please define it in whatever way is most meaningful to you. At the top of the ladder are the people who have the highest standing in their community. At the bottom are the people who have the lowest standing in their community.



7 Where would you put yourself on this ladder?

Select number ranging from 1-10.



Think of this ladder as representing where people stand in Australia.
At the top of the ladder are the people who are best off- those who have the most money, the most education and the most respected jobs. At the bottom are the people are the worst off- who have the least money, least education, and the least respected jobs or no job. The lower you are, the closer you are to the people at the very bottom.

8	Where would you put yourself on this ladder?	*Select number ranging from 1-10*
9	Are you interested in losing weight?	Yes No
10	(if yes): What is the primary reason you are interested in losing weight?	For health reasons Appearance Other *(please specify)*
11	Do you do your own cooking/meal preparation at home?	*(Choose one of the following answers)* Rarely or none of the time Some of the time (1-2 days a week) Much of the time (3-4 days a week)

		Most of the time (5-7 days a week)
		(Choose one of the following answers)
		Rarely or none of the time
		Some of the time (1-2 days a week)
		Much of the time (3-4 days a week)
12	How often do you ‘eat out’ (e.g., at a restaurant/café, etc.)?	Most of the time (5-7 days a week)
		(Choose one of the following answers)
		Rarely or none of the time
		Some of the time (1-2 days a week)
	How often do you eat ‘take away’ or ‘fast food’ (e.g., McDonalds,	Much of the time (3-4 days a week)
13	Hungry Jacks, Subway)?	Most of the time (5-7 days a week)
Please select the option from the following statement that best describes you		
		Very true for me
		Somewhat true for me
		Somewhat false for me
14	When I am doing well at something I love to keep at it	Very false for me
		Very true for me
		Somewhat true for me
		Somewhat false for me
15	When I get something I want, I feel excited and energised	Very false for me
		Very true for me
		Somewhat true for me
	When I see an opportunity for something I like I get excited right	Somewhat false for me
16	away	Very false for me
		Very true for me
		Somewhat true for me
		Somewhat false for me
17	When good things happen to me, it affects me strongly	Very false for me
	I feel worried when I think I have done poorly at something	Very true for me
18	important	Somewhat true for me

		Somewhat false for me
		Very false for me
		Very true for me
		Somewhat true for me
		Somewhat false for me
19	It would excite me to win a contest	Very false for me

For each of the following statements, please indicate if you felt this way during the past week

		Rarely or none of the time (less than 1 day)
		Some of the time (1-2 days a week)
		Much of the time (3-4 days a week)
20	I was bothered by things that usually don't bother me	Most of the time (5-7 days a week)
		Rarely or none of the time (less than 1 day)
		Some of the time (1-2 days a week)
		Much of the time (3-4 days a week)
21	I had trouble keeping my mind on what I was doing	Most of the time (5-7 days a week
		Rarely or none of the time (less than 1 day)
		Some of the time (1-2 days a week)
		Much of the time (3-4 days a week)
22	I felt depressed	Most of the time (5-7 days a week
		Rarely or none of the time (less than 1 day)
		Some of the time (1-2 days a week)
		Much of the time (3-4 days a week)
23	I felt that everything I did was an effort	Most of the time (5-7 days a week
		Rarely or none of the time (less than 1 day)
		Some of the time (1-2 days a week)
		Much of the time (3-4 days a week)
24	My sleep was restless	Most of the time (5-7 days a week
		Rarely or none of the time (less than 1 day)
		Some of the time (1-2 days a week)
25	I was happy	Much of the time (3-4 days a week)

		Most of the time (5-7 days a week
		Rarely or none of the time (less than 1 day)
		Some of the time (1-2 days a week)
		Much of the time (3-4 days a week)
26	I felt lonely	Most of the time (5-7 days a week
		Rarely or none of the time (less than 1 day)
		Some of the time (1-2 days a week)
		Much of the time (3-4 days a week)
27	I felt hopeful about the future	Most of the time (5-7 days a week
		Rarely or none of the time (less than 1 day)
		Some of the time (1-2 days a week)
		Much of the time (3-4 days a week)
28	I felt fearful	Most of the time (5-7 days a week
		Rarely or none of the time (less than 1 day)
		Some of the time (1-2 days a week)
		Much of the time (3-4 days a week)
29	I could not get going	Most of the time (5-7 days a week

Please indicate how much you agree with the following statements

		I don’t agree
		I agree a little
		I agree somewhat
	I find myself thinking about food even when I am not physically	I agree quite a bit
30	hungry	I strongly agree
		I don’t agree
		I agree a little
		I agree somewhat
	I get more pleasure from eating than I do from almost anything	I agree quite a bit
31	else	I strongly agree
		I don’t agree
32	If I see or smell a food I like, I get a powerful urge to have some	I agree a little

		I agree somewhat I agree quite a bit I strongly agree
33	When I'm around a fattening food I love, it's hard to stop myself from at least tasting it	I don't agree I agree a little I agree somewhat I agree quite a bit I strongly agree
34	It's scary to think of the power that food has over me	I don't agree I agree a little I agree somewhat I agree quite a bit I strongly agree
35	When I know a delicious food is available, it's hard to stop myself from thinking about having some	I don't agree I agree a little I agree somewhat I agree quite a bit I strongly agree
36	I love the taste of certain foods so much that I can't avoid eating them, even if they're bad for me	I don't agree I agree a little I agree somewhat I agree quite a bit I strongly agree
37	Just before I taste a favourite food, I feel intense anticipation	I don't agree I agree a little I agree somewhat I agree quite a bit I strongly agree
Please indicate the extent to which you agree that the following items describe you		
38	When I eat a delicious food, I focus a lot on how food it tastes	I don't agree

		I agree a little I agree somewhat I agree quite a bit I strongly agree
39	Sometimes, when I'm doing everyday activities, I get an urge to et "out of the blue" (for no apparent reason)	I don't agree I agree a little I agree somewhat I agree quite a bit I strongly agree
40	I think I enjoy eating a lot more than most other people	I don't agree I agree a little I agree somewhat I agree quite a bit I strongly agree
41	Hearing someone describe a great meal makes me really want to have something to eat	I don't agree I agree a little I agree somewhat I agree quite a bit I strongly agree
42	It seems like I have food on my mind a lot	I don't agree I agree a little I agree somewhat I agree quite a bit I strongly agree
43	It is very important to me that the foods I eat are as delicious as possible	I don't agree I agree a little I agree somewhat I agree quite a bit I strongly agree
44	Before I eat a favourite food, my mouth tends to fill with saliva	I don't agree

		I agree a little I agree somewhat I agree quite a bit I strongly agree

The next questions ask about your eating habits in the past year. People sometimes have difficulty controlling their intake of certain foods such as:
-Sweets like ice cream, chocolate, donuts, cookies, cake, candy;
-Starches like white bread, rolls, pasta and rice;
-Salty snacks like chips, pretzels and crackers;
-Fatty foods like steak, bacon, hamburgers, cheeseburgers, pizza and French fries;
-Sugary drinks like soft drinks, red bull.
When the following questions ask about 'certain foods', please think of ANY foods similar to those listed above, or any other foods you have had a problem with in the past year

45	I find that when I start eating certain foods, I end up eating much more than planned	Never Once a month 2-4 times a month 2-3 times a week 4 or more times a week, or daily
46	I find myself continuing to consume certain foods, even when I am no longer hungry	Never Once a month 2-4 times a month 2-3 times a week 4 or more times a week, or daily
47	I eat to the point where I feel physically ill	Never Once a month 2-4 times a month 2-3 times a week 4 or more times a week, or daily
48	Not eating certain types of food, or cutting down on certain types of food, is something that I worry about	Never Once a month 2-4 times a month

		2-3 times a week 4 or more times a week, or daily
49	I spend a lot of time feeling sluggish or fatigued from overeating	Never Once a month 2-4 times a month 2-3 times a week 4 or more times a week, or daily
50	I find myself constantly eating certain foods throughout the day	Never Once a month 2-4 times a month 2-3 times a week 4 or more times a week, or daily
51	I find that when certain foods are not available, I will go out of my way to obtain them. For example, I will drive to the store to purchase certain foods, even though I have other options available to me at home	Never Once a month 2-4 times a month 2-3 times a week 4 or more times a week, or daily
52	There have been times when I’ve consumed certain foods so often or in large quantities, that I started to eat food instead of working, spending time with my family or friends, or engaging in other important activities that I enjoy	Never Once a month 2-4 times a month 2-3 times a week 4 or more times a week, or daily
53	There have been times when I’ve avoided professional or social situations where certain foods are available, because I was afraid I would overeat	Never Once a month 2-4 times a month 2-3 times a week 4 or more times a week, or daily
54	There have been times when I’ve avoided professional or social situations because I was not about to consume certain foods there	Never Once a month 2-4 times a month

		2-3 times a week 4 or more times a week, or daily
55	I have had withdrawal symptoms such as agitation, or other physical symptoms when I cut down or stopped eating certain foods (please do not include withdrawal symptoms caused by cutting down caffeinated beverages such as soft drink, coffee, tea, energy drinks etc.)	Never Once a month 2-4 times a month 2-3 times a week 4 or more times a week, or daily
56	I have found that I have elevated desire for or urges to consume certain foods when I cut down or stop eating them	Never Once a month 2-4 times a month 2-3 times a week 4 or more times a week, or daily
57	My behaviour with respect to food and eating causes me significant distress	Never Once a month 2-4 times a month 2-3 times a week 4 or more times a week, or daily
58	I experience significant problems in my ability to function effectively (daily routine, job, school, social activities, family activities, health difficulties) because of food and eating	Never Once a month 2-4 times a month 2-3 times a week 4 or more times a week, or daily
Please select the option from the following scale that best describes how often you have felt/behaved this way in the last 12 months		
59	My food consumption has caused significant psychological problems such as depression, self-loathing, anxiety, or guilt	No Yes
60	My food consumption has caused significant physical problems or made a physical problem worse	No Yes
61	I kept consuming the same types of food or the same amount of food even though I was having emotional and/or physical problems	No Yes

62	Over time, I have found that I need to eat more and more to get the feeling I want, such as reduced negative emotions, or increased pleasure	No Yes
63	I have found that eating the same amount of food does not reduce my negative emotions or increase pleasurable feelings the way it used to	No Yes
64	I want to cut down or stop eating certain kinds of food	No Yes
Please select the option from the following scale that best describes how often you have felt/behaved in this way in the last 12 months		
65	How many times in the past year did you try to cut down or stop eating certain foods altogether?	None One time Two times Three times Four times Five or more times
The next two questions relate to healthy food choices- this means choosing, for example, a low-calorie option (e.g., an apple) over a high-calorie option (e.g., a chocolate bar) when you decide to have a meal or snack. Imagine yourself in that situation, and think about the outcomes of your food choice		
66	If you were to experience costs from making a healthy food choice, when do you think you would notice them?	When I am thinking about whether or not to make a healthy food choice When I make the decision to make a healthy food choice While I am getting ready to make a healthy food choice While I am making a healthy food choice After making a healthy food choice once After making healthy food choices regularly for a week After making healthy food choices regularly for a year After making healthy food choices regularly for several years After making healthy food choices regularly for several decades
67	If you were to experience benefits from making a healthy food choice, when do you think you would notice them?	When I am thinking about whether or not to make a healthy food choice When I make the decision to make a healthy food choice While I am getting ready to make a healthy food choice While I am making a healthy food choice

		After making a healthy food choice once After making healthy food choices regularly for a week After making healthy food choices regularly for a year After making healthy food choices regularly for several years After making healthy food choices regularly for several decades

The next questions are about whether you have intentions or plans to change your diet in the future

68	I intend to make more healthy food choices	Strongly disagree Disagree Neither agree not disagree Agree Strongly agree
69	I am confident that I could make more healthy food choices even if it was difficult	Strongly disagree Disagree Neither agree not disagree Agree Strongly agree
70	I have made a detailed plan on when, where and how to implement more healthy food choices	Strongly disagree Disagree Neither agree not disagree Agree Strongly agree
71	I have made a detailed plan on how to make healthy food choices even if something gets in the way	Strongly disagree Disagree Neither agree not disagree Agree Strongly agree

The next questions are about yourself. Using the scale provided, please indicate how much each of the following statements reflects how you typically are

72	I am good at resisting temptation	1- Not at all 2

		3
		4
		5- Very much
		1- Not at all
		2
		3
		4
73	I have a hard time breaking bad habits	5- Very much
		1- Not at all
		2
		3
		4
74	I am lazy	5- Very much
		1- Not at all
		2
		3
		4
75	I say inappropriate things	5- Very much
		1- Not at all
		2
		3
		4
76	I do certain things that are bad for me if they are fun	5- Very much
		1- Not at all
		2
		3
		4
77	I refuse things that are bad for me	5- Very much
		1- Not at all
78	I wish I had more self-discipline	2

		3
		4
		5- Very much
		1- Not at all
		2
		3
		4
79	People would say that I have iron self-discipline	5- Very much
		1- Not at all
		2
		3
		4
80	Pleasure and fun sometimes keep me from getting work done	5- Very much
		1- Not at all
		2
		3
		4
81	I have trouble concentrating	5- Very much
		1- Not at all
		2
		3
		4
82	I am able to work effectively towards long-term goals	5- Very much
		1- Not at all
		2
		3
	Sometimes I can’t stop myself from doing something, even if I	4
83	know it is wrong	5- Very much
		1- Not at all
84	I often act without thinking through all the alternatives	2

		3
		4
		5- Very much
The next questions are about how you typically deal with tasks		
		Not at all true
		Barely true
		Somewhat true
85	I can concentrate on one activity for a long time if necessary	Completely true
		Not at all true
		Barely true
	When I am distracted from an activity, I don't have any problem	Somewhat true
86	coming back to the topic quickly	Completely true
		Not at all true
		Barely true
	If an activity arouses my feelings too much, I can calm myself	Somewhat true
87	down so that I can continue with the activity soon	Completely true
		Not at all true
		Barely true
	If an activity requires a problem-oriented attitude, I can control my	Somewhat true
88	feelings	Completely true
		Not at all true
		Barely true
	It is difficult for me to suppress thoughts that interfere with what I	Somewhat true
89	need to do	Completely true
		Not at all true
		Barely true
	I can control my thoughts from distracting me from the task at	Somewhat true
90	hand	Completely true
		Not at all true
91	When I worry about something, I cannot concentrate on an activity	Barely true

		Somewhat true Completely true
92	After an interruption, I don't have any problem resuming my concentrated style of working	Not at all true Barely true Somewhat true Completely true
93	I usually have a whole bunch of thoughts and feelings that interfere with my ability to work in a focused way	Not at all true Barely true Somewhat true Completely true
94	I stay focused on my goal and don't allow anything to distract me from my plan of action	Not at all true Barely true Somewhat true Completely true

Most health organisations suggest that a healthy diet is one that consists of at least five portions (servings of fruit and vegetables) per day

95	On how many days during the last week have you eaten at least five portions (servings) of fruit and vegetables	0 out of 7 1 out of 7 2 out of 7 3 out of 7 4 out of 7 5 out of 7 6 out of 7 7 out of 7

The next questions ask about your opinions on eating certain foods such as:
-Sweets like ice cream, chocolate, donuts, cookies, cake, candy;
-Starches like white bread, rolls, pasta and rice;
-Salty snacks like chips, pretzels and crackers;
-Fatty foods like steak, bacon, hamburgers, cheeseburgers, pizza and fries;
-Sugary drinks like soft drinks, red bull.
When the following questions ask about 'certain foods', please think of any foods similar to those listed above.

96	To what extent do you agree with the following statement? In my opinion, it is okay for people to consume certain foods regularly	Strongly disagree Disagree Neither agree nor disagree Agree Strongly agree
97	In your opinion, do people in general approve or disapprove of people regularly (i.e., at least three times per week) consuming certain foods?	Strongly disapprove Disapprove Neither approve nor disapprove Approve Strongly approve
98	Think of five people you feel most close to. These could be your partner, family members, friends, colleagues or acquaintances. Thinking of the five people, how many of them, if any, consume certain foods regularly (i.e., at least three times per week)?	0 (none of them) 1 2 3 4 5 (all of them) Don’t know
99	Do you think that consuming certain foods is uncommon… common?	Very uncommon Uncommon Neither common, nor uncommon Common Very common
How do (you think) each of the following people would feel about your current eating pattern?		
100	Your immediate family	Strongly disapprove Disapprove Neither approve nor disapprove Approve Strongly approve Not applicable
101	Your close friends	Strongly disapprove

		Disapprove Neither approve nor disapprove Approve Strongly approve Not applicable
102	Your partner or spouse	Strongly disapprove Disapprove Neither approve nor disapprove Approve Strongly approve Not applicable

Appendix 6.1. Chapter 6: MunchIO Protocol

Title: Right on Cue: Technologies for Managing Unhealthy Behavioural Cues, A Pilot Study

Scientific title: A pilot evaluation of MunchIO: A smartphone app for reducing unhealthy snacking habits

Project Team Roles & Responsibilities

Dr. Kristy de Salas: Chief Investigator. Supervision, Design, Analysis, Manage Project.

Dr. Ian Lewis: Software Development, Design, Analysis, Intervention Content.

Associate Professor Stuart Ferguson: Supervision, Design, Analysis, Intervention Content.

Ms. Katherine Elliston: Design, Analysis, Intervention Content.

Mr. Anthony Smith: Software Development, Design, Analysis, Intervention Content.

Resources:

Pre-developed MunchIO app.

Aims

The primary objective of this research is to pilot an innovative mobile application named MunchIO for reducing unhealthy snacking behaviours through behaviour change techniques know as cue monitoring and implementation intentions. In piloting the MunchIO app, the focus of this research is to examine usability design. Understanding how the MunchIO app is utilised by participants will be useful to further advance the design of such technologies prior to deployment in larger scale efficacy trials. Usability within this research study is based on the Health IT Usability Evaluation framework, which considers metrics of effectiveness, efficiency, perceived ease of use and perceived usefulness (Brown, Yen, Rojas & Schnall, 2013).

Research Questions

Research questions for the pilot trial were derived from the Health IT Usability Evaluation framework and previous literature as follows:

1. Can the MunchIO app successfully incorporate cue monitoring and implementation intentions?
2. Does the MunchIO app:
   - Reduce unhealthy snacking behaviour (compared to participants using an equivalent of a commercial app within this study)?
   - Alter underlying psychological processes believed to be important in determining snacking behaviour?
   - Serve as an efficient tool for reducing unhealthy snacking behaviours?
3. Is the MunchIO app acceptable to users in terms of:
   - Perceived ease of use?
   - Perceived usefulness?

As this is a pilot trial, research questions will be framed in the context of usability investigation and improvement. Research questions relating to the MunchIO app intervention's effectiveness will require further investigation in larger scale efficacy trials.

Background

Health behaviours, often referred to as lifestyle risk factors, are a key determinant for an individual's propensity to develop many non-communicable diseases (Conner, 2002). In Australia, dietary risk factors account for the highest attributable factor in disease burden followed by high body mass index and tobacco consumption (AIHW, 2014). Psychological research has consequently developed formal health behaviour change techniques for individuals to address risk factors (Michie, Atkins &

West, 2015; Michie, et al., 2014). A key risk factor of non-communicable diseases is obesity and being overweight resulting from caloric imbalance. In order to reduce caloric balance, either expenditure needs to be increased (physical activity) or intake be decreased (dietary behaviours). This project focuses on caloric intake, in particular that resulting from discretionary foods ("snacks"), which are estimated to contribute about 35% of daily caloric intake (AIHW, 2014). One promising approach to manage snacking behaviour involves cue-monitoring and implementation intentions (Adriaanse, de Ridder & de Witt, 2009; Verhoeven et al., 2014). Cue-monitoring refers to identifying habitual cues that trigger unhealthy behaviour (Adriaanse et al., 2009). Implementation intentions then refer to planning more adaptive behavioural responses when the cues are encountered in order to replace the unhealthy behaviour (Gollwitzer, 1999). These strategies have been suggested as supporting the formation of healthy habits. The proposed mHealth application will support this in a novel way by identifying personally relevant cues for unhealthy behaviours via automated self-monitoring in combination with prompting implementation intentions to overcome the association between these individual cues and snacking.

Mobile health (mHealth) apps are an emerging technology that is being increasingly leveraged for the purpose of health behaviour interventions. Currently, both the Apple App Store (Apple, 2015) and Google Play Store (Google, 2015) have entire subsections dedicated to popular health and fitness apps. Motivation for mHealth apps to deliver health behaviour interventions is conceivably based on widespread smartphone ownership, accessibility and innovation. Ownership of smartphones is prevalent within Australia at 64.6% (Sydney Morning Herald, 2013) with the rest of the world estimated at 22% (Business Insider, 2013). Accessibility of smartphones is also high with a study by Dey et al. (2011) indicating that most people keep their smartphone within arm's reach or the same room at around 90% of all times. Innovation is also another factor with mHealth apps for health behaviour interventions being able to leverage smartphone capabilities such as accelerometers, global positioning systems and internet-based features to enhance intervention strategies (Kratzke & Cox, 2012). This suggests that mHealth applications have a very good potential for being important components of effective public health measures.

Systematic reviews of mHealth apps for health behaviour change, however, reveal that many implement minimal formal health behaviour change techniques. Findings from mHealth app systematic reviews have found minimal formal health behaviour change techniques in areas such as alcohol (Cohn, Hunter-Reel, Hagman & Mitchell, 2011), diets (Direito, et al., 2014; West et al., 2013), physical activity (Conroy, Yang & Maher, 2014; Cowan et al., 2012; Direito et al., 2014; Middelweerd et al., 2014) and smoking (Abroms, Padmanabhan, Thaweethai & Phillips, 2011). The widespread practice of mHealth apps implementing minimal health behaviour change techniques greatly calls into question their effectiveness and validity. Authors of these systematic reviews have consequently called for mHealth apps to be developed on evidence-based theories.

The main purpose motivating this research therefore is to align an mHealth app with evidence-based health behaviour change techniques to support reductions in discretionary food choices (snacks). Further, the mHealth app will be the first to implement both cue monitoring and implementation intention strategies in one comprehensive mobile framework. The effectiveness of the mHealth app will be tested in a group of participants classified as overweight or obese, as weight reductions are indicated in this group of participants. Feedback for the mHealth app will finally be elicited from research participants to create generic mHealth app development guidelines for public dissemination.

Methods: Phase I: The pilot trial of the app

Design

The MunchIO app will be trialled as an intervention for those wanting to begin a diet with the aim of reducing unhealthy snacking. After installing the MunchIO app, participants will be prompted to complete an enrolment process that collects some personal information, including; name, email address, age, sex, height, weight, waist circumference, the reason for downloading the app, and an overview of their current eating habits. Once the individual's details are entered into the app, enrolment in the study is complete. Participants will then be asked to begin their programme.

Participants will be randomised into either an intervention or control group. Participants in the intervention group will receive full access to the MunchIO app, including novel cue monitoring and implementation intention features aimed at planning against unhealthy snacking. Participants in the control group will have restricted access to content in the MunchIO app; they will not receive access to the cue monitoring and implementation intention content. The app otherwise behaves identically and includes the same behavioural support content (including snack analytics tools and general healthy eating advice based on the Australian Dietary Guidelines information).

During the first week of monitoring, all participants will log all snack intake, respond to randomised prompts and complete an evening meal summary in the MunchIO app (see Figure 1). On completion of the first week, participants randomised to the intervention condition will receive a cue monitoring prompt containing their top three snacking cues requiring implementation intention planning (if-then style plans). The cue monitoring component will utilise an odds ratio algorithm between the snack entries and random prompts to identify top cue exposures that lead to snacking on discretionary choices (see Figure 2) (Szumilas, 2010; Verhoeven et al., 2014).

Implementation intentions then refer to creating plans that read in the format of "if I am stressed, I will go for a walk". Intervention participants will be reminded daily of their cue monitoring and implementation intentions. Participants are not compelled to complete any particular activity, although they will be prompted to use the app daily, by way of reminder.

After 28-days of monitoring snacking the trial will end and participants will be asked to complete a survey regarding their eating habits and experiences with the app. In addition, two usability surveys will also be distributed. At this point, all participants including the control group will receive full access to the app, including both the intervention cue-monitoring and implementation features. Participants will retain full access to the app beyond the 28-day trial period.

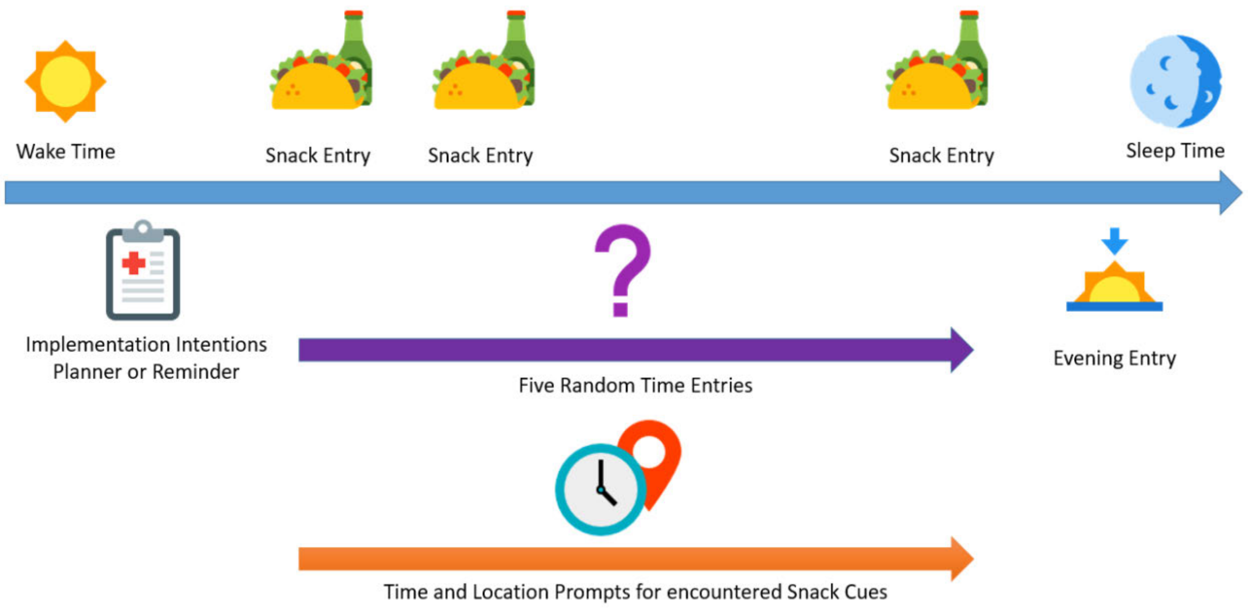


Figure 1. Daily use of the MunchIO app

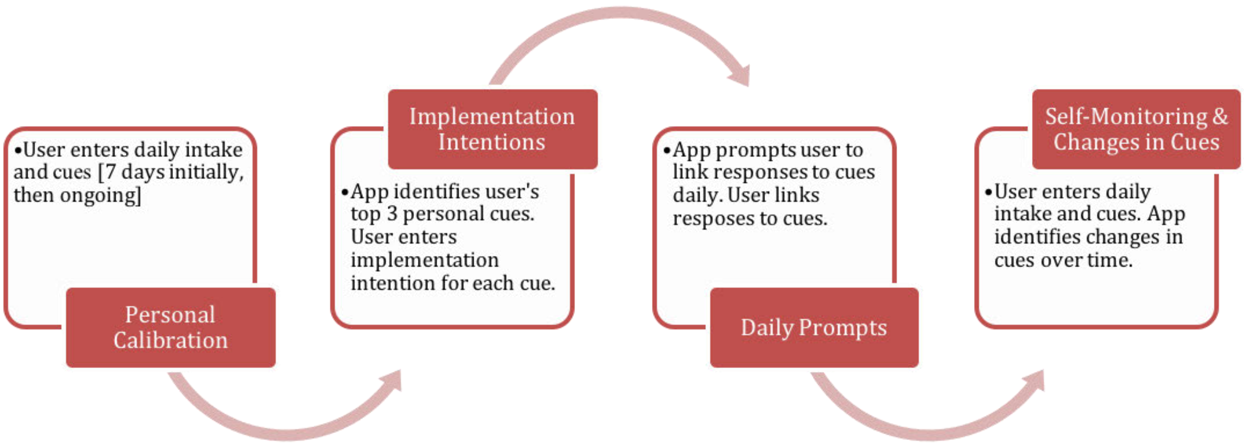


Figure 2. MunchIO Core Features

Setting

The proposed pilot trial will be run entirely online. The MunchIO app will be made publicly available on both the Google Play and iTunes app stores. The end user license agreement (currently being drafted by the University of Tasmania Legal Services) will explain the nature of the trial and that by using the app the user consents to their de-identified data being collected and used for research purposes.

Participants

Eligibility criteria

A community sample of individuals interested in reducing their unhealthy snacking habits will be recruited through online and poster advertising. Interested individuals will download the MunchIO app and complete a set of screening questions. To be eligible for enrolment interested individuals will need to report via the app that they are a) aged between 18 and 65 years old; b) able to read English; c) have a BMI in the overweight/obese range and d) own a compatible mobile phone. Individuals will be excluded from the study if they report a) they have an Eating Disorder and/or b) are not using the MunchIO app for a serious attempt to reduce unhealthy snacking habits. Participants will also need to provide consent via an in-built end user licence agreement before starting research tasks. Individuals who are ineligible to participate in the MunchIO app study will still be able to utilise the app after providing consent. Allowing the MunchIO app to be utilised by individuals regardless of eligibility removes potential motivation for individuals to be deceptive regarding eligibility to access the app. Ineligible participants will be excluded from subsequent data analysis and participation in the focus groups.

Individuals will undergo a second screening process prior to being invited to participate in the focus groups. To be eligible to participate in the focus groups, individuals must, in addition to the above criteria, have completed at least three days of monitoring using the app. Individuals who have completed less than the three days of monitoring will not receive an invitation to participate in a focus group discussion.

Sample size and justification

As this is a pilot trial, with the primary aim to seek feedback on the usability of the MunchIO app, and test recruitment methods for a larger-scale roll out of the app, the aim is to have 100 people enrol in the trial. Previous studies examining and reviewing the use of mobile technologies to change eating behaviours (e.g., Boh et al., 2016; Carter, Burley & Cade, 2014) have found similar sample sizes to be adequate in detecting group differences in behaviour after interventions. However, it is not the aim of this study to make claims regarding efficacy.

Recruitment

Recruitment for the trial will take place primarily through online advertising using various social media platforms such as Facebook and Twitter. Poster advertisements for the study will also be displayed around the University of Tasmania Furthermore, the project will be promoted/communicated via correspondence with relevant peak bodies (e.g. Diabetes Tasmania) and local media outlets (e.g. The Mercury newspaper). Advertising, wherever possible, will be targeted towards individuals who are overweight/obese. Recruitment will take place after ethical approval is granted and continue throughout the study.

Measures

Participants will be asked to complete a number of activities in the MunchIO app that serve as measures for presented research questions. First, research participants will complete an eating habits survey both at the beginning and conclusion for comparison purposes. The eating habits survey will assist to provide preliminary data regarding research question 2b. Snacking data will also be continually collected as a means to provide preliminary data for research question 2a. In particular, the pilot trial will aim to see if there are any preliminary differences in snacking frequencies over time between the intervention and control group. Metadata including time spent entering snacks and related data will serve to investigate efficiency regarding question 2c. Furthermore, two usability surveys will be distributed at the end of the 28-day period to collect data relating to research questions 3a and 3b.

Data collection

Data collection for MunchIO app usage will automatically occur through transmission to a secure webserver hosted in the University of Tasmania supported Nectar Research Cloud platform. The proposed trial will be open for participation from December 2017 to May 2018. Individual participants will participate for a period of approximately 28 days.

All data will be stored on the previously mentioned secure webserver. As with all electronic data collected, data will be stored until no longer necessary but for at least

5 years. Analysis of research data will also involve participant data being stored on the Investigator's university computers.

For all data analysis, participants data will be re-identifiable. Participants will be assigned a number used to identify their data records. Separate to the analysis, some basic details including name, email address and date of birth will be stored in a separate database table. This information will be used for contact purposes only. Namely, to invite participants to the focus groups (see description of focus groups below). Reported date of birth will used to ensure participants are over the age of 18, rendering them eligible to participant in the trial. All of this data will be stored securely and no attempt will be made to link these details to an individual's recorded data.

Risks

There are minimal risks and burdens associated with this research. In some individuals, changing eating habits may result in some irritability. However, this is a result of a new diet rather than the research itself. It is intended that the MunchIO app, through the support content it provides, may help manage such irritability. Both the intervention and control group receive support consistent with current standards of care.

The contact information for the Buttery Foundation will be listed on the app, which will serve as a referral should anyone need psychological support during their participation period.

Data analysis

Data analysis for the pilot trial will aim to perform a preliminary analysis for the MunchIO app's effectiveness and usability. Preliminary analysis for the MunchIO app's effectiveness in reducing unhealthy snacking habits will utilise multi-level logistic regression analysis, situational antecedents and linear regression analysis. Multi-level logistic regression analysis will be used to examine situational cues that trigger snack intake. Situational antecedents will be used to predict snacking occasions within each individual's data. Linear regression analysis will be used to test for the association between stimulus control and snacking, and to examine differences between the control and intervention groups. Acknowledging that 100 participants is a small sample size for statistical power purposes, the aim of this analysis will be used to inform and support usability findings. We do, however, anticipate that the intake of unhealthy snacks will differ between the two conditions with those in the intervention condition decreasing snack intake more rapidly and abstaining from unhealthy snacks for longer than those in the control condition.

Usability analysis will utilise both ANOVA (one-way) and grounded theory principles. The ANOVA (one-way) will be utilised to detect significant difference between the two groups on usability survey Likert scale items. The grounded theory principles of open coding, axial coding and selective coding will be utilised to develop feedback into encompassing themes that describe the app's usage.

Methods: Phase II: The focus groups

Design

Focus groups will further evaluate the MunchIO app by eliciting participant experiences and feedback. Participants will be invited to attend one online focus group each running for 40-60 minutes after utilising the app for a period of at least three days. The focus groups will be overseen and conducted by qualified members of the research team. The CI has a range of experience in qualitative research including a number of studies focused on technology evaluation interviews and focus groups. Mr Smith has also utilised qualitative interview research to evaluate a mobile app for alcohol and risk-taking monitoring. In each focus group, the participants will discuss the MunchIO app's features based primarily on the Health IT Usability Evaluation Model.

Setting

The focus groups will be run entirely online using the Google Hangouts on Air platform.

Participants

It is anticipated that up to five focus groups will be run, each including 10 participants, this is subject to invitation responses.

Eligibility criteria

Participants will be eligible if they met the pilot trial's eligibility requirements and have also completed at least three days monitoring using the MunchIO app.

Sample size and justification

The proposed sample size (*N*=50; up to 10 participants per group) was determined as ideal to address the research questions evaluating perceived ease of use and usefulness. We anticipate that such a participant sample size will identify a saturation of themes around the MunchIO app's utilisation. We base this assumption upon Nielsan's discount usability testing principles (Nielson, 1995; Virzi, 1992).

Recruitment

On completion of the first three days of app monitoring, users of the MunchIO app will be invited via email to voluntarily participate in an online focus group (see Figure 3).

Measures

Participants will engage in a semi-structured focus group discussion based around the Health IT Usability Evaluation framework. Utilising the Health IT Usability Evaluation framework provides a structured method for discussing the topics surrounding perceived ease of use (research question 3a) and perceived usefulness (research question 3b) including their related sub-criteria. The purpose of the focus group discussions will be to elicit a set of feedback, concepts and themes to address previously described research questions. The questions that will form the basis of the interview.

Data collection

Data collection will take place online with focus groups automatically recorded through the Google Hangouts on Air platform. Mr Smith will moderate focus groups while being overseen by the CI due to relevant expertise and qualifications. The focus groups themselves will be conducted from January 2018 through to May 2018 as enough participants become available. All focus groups will be immediately transcribed with redacted versions given to participants for review and feedback purposes. No participant will be able to see each other's responses.

Data will be stored on secure workstations at the University of Tasmania Sandy Bay campus and will be stored until no longer necessary, but for at least 5 years, before being destroyed.

Risks

Risks in the focus group phase are very minimal when discussing the MunchIO app. Research participants are invited to participate on a voluntary basis and it will be made clear that they can withdraw at any point. Furthermore, the focus groups themselves are unlikely to raise issues of a personal or uncomfortable nature.

Data analysis

The primary purpose of the focus groups is to seek feedback on the usability of the app, focusing specifically on the perceived ease of use, usefulness and efficiency of the MunchIO app. To explore these topics, we will apply principles of grounded theory to identify emerging themes common across participants experiences. Participants experiences will be grouped as being positive, neutral or negative. The grounded theory approach in this study will focus on the process of open coding, axial coding and selective coding. Focus group themes are expected to relate closely to the Health IT Usability Evaluation framework as this model will be utilised to support the identification and categorisation of codes.

Quality control and feasibility

The project has been peer reviewed as part of Mr Smith's PhD Confirmation and Annual Review processes. Further yearly annual reviews will take place to monitor relevant progress. Based on previous experience it is anticipated that we can recruit and enrol the proposed sample within the allotted time.

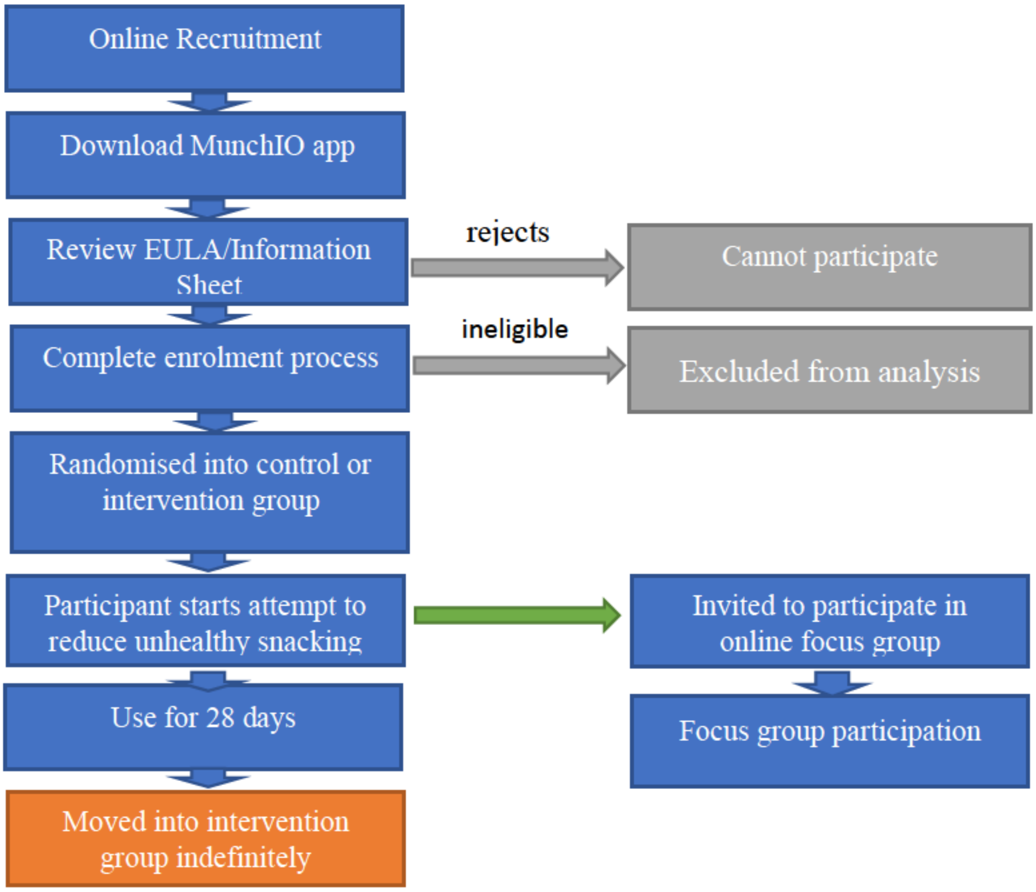


Figure 3. Flow chart describing the phases of participation in the study.

References

Abroms, L., Padmanabhan, N., Thaweethai, L. & Phillips, T. (2011). iPhone apps for smoking cessation: A content analysis. *American Journal of Preventive Medicine, 40*(3): 279-285.

Adriaanse, M., de Ridder D. & de Wit, J. (2009). Finding the critical cue: Implementation intentions to change one's diet work best when tailored to personally relevant reasons for unhealthy eating. *Personality and Social Psychology Bulletin, 30*(1): 60-71.

Apple (2015). Health and Fitness- App store downloads on iTunes. Available at https://itunes.apple.com/au/genre/ios-health-fitness/id6013?mt=8 Accessed June 17, 2015.

Australian Instiute of Health and Welfare (2014). Australia's Health 2014. Available at http://www.aihw.gov.au/publication-detail/?id=60129547205 Accessed June 2, 2015.

Boh, B., Lemmens, L., Jansen, A., Nederkoorn, C., Kerkhofs, V., Spanakis, G., Weiss, G. & Roefs, A. (2016). An ecological momentary intervention for weight loss and healthy eating via smartphone and internet: Study protocol for a randomised controlled trial. *Trials, 17*(1).

Brown, W., Yen, P., Rojads, M. & Schnall, R. (2013). Assessment of the Health IT usability evaluation model (Health- ITUEM) for evaluating mobile health (mHealth) technology. *Journal of Biomedical Informatics, 46*(6): 1080-1087.

Business Insider (2013). One in every 5 people in the world own a smartphone, one in every 17 own a tablet (chart). Business Insider. Available at http://www.businessinsider.com.au/smartphone-and-tablet-penetration-2013-10 (Accessed July 19, 2015).

Carter, M., Burley, V. & Cade, J. (2014). Handheld electronic technology for weight loss in overweight/obese adults. *Current Obesity Reports, 3*(3): 307-315.

Cohn, A., Hunter-Reel, D., Hagman, B. & Mitchell, J. (2011). Promoting behaviour change from alcohol use through mobile technology: The future of ecological momentary assessment. *Alcoholism: Clinical and Experimental Research, 35*(5): 2209-2215.

Conner, M. (2002). Health behaviours. Available at http://userpage. fu-berlin. de/~ schuez/folien/conner2002. pdf.

Conroy, D., Yang, C-H. & Maher, J. (2014). Behavior change techniques in top-ranked mobile apps for physical activity. *American Journal of Preventive Medicine, 46*(6): 649-652.

Cowan, L., Van Wagenen, S., Brown, B., Hedin, R., Senio-Stephan, Y., Hall, P. & West, J. (2012). Apps of steel: Are exercise apps providing consumers with realistic expectations? A content analysis of exercise apps for presence of Behavior Change Theory. *Health Education & Behavior.*

Dey, A., Wac, K., Ferreira, D., Tassini, K., Hong, J-H. & Ramos, J. (2011). Getting closer: An empirical investigation of the proximity of user to their smart phones. In Proceedings of the 13th international conference on ubiquitous computing ACM: 163-172.

Direito, A., Dale, L., Shields, E., Dobson, R., Whittaker, R. & Maddison, R. (2014). Do physical activity and dietary smartphone application incorporate evidence-based behaviour change techniques? *BMC Public Health, 14*(1): 646.

Gollwitzer, P. (1999). Implementation intentions: Strong effects of simple plans. *American Psychologist, 54*(7): 493.

Google (2015). Health & Fitness- Android apps on Google Play. Available at https://play.google.com/store/apps/category/HEALTH_AND_FITNESS Accessed June 17, 2015.

Kratzke, C. & Cox, C. (2012). Smartphone technology and apps: Rapidly changing health promotion. *International Journal of Health Education*, *15*: 72.

Michie, S., Atkins, L. & West, R. (2015). The behaviour change wheel: A guide to designing interventions.

Mitchie, S., West, R., Campbell, R., Brown, J. & Gainforth, H. (2014). ABC of behaviour change theories.

Middelweerd, A., Mollee, J., van der Wal, C., Brug, J. & Te Velde, S. (2014). Apps to promote physical activity among adults: A review and content analysis. *International Journal of Behavioral Nutrition and Physical activity, 11*(1): 97.

Nielsen, J. (1995). Applying discount usability engineering. *IEEE software*, *12*(1): 98-100.

Szumilas, M. (2010). Explaining Odds Ratios. *Journal of the Canadian Academy of Child and Adolescent Psychiatry*, *19*(3): 227.

The Sydney Morning Herald (2013). Two-thirds of Aussies own a smartphone: Report. Available at: http://www.smh.com.au/digital-life/mobiles/twothirds-of-aussies-own-a-smartphone-report-20130729-2quj1.html Accessed July 19, 2015.

Verhoeven, A., Adriaanse, M., de Vet, E., Fennis, B. & de Ridder, D. (2014). Identifying the “if” for “if-then” plans: Combining implementation intentions with cue-monitoring targeting unhealthy snacking behaviour. *Psychology & Health*, *29*(12): 1476-1492. http://www.ncbi.nlm.nih.gov/pubmed/25099386

Virzi,R. (1992). Refining the test phase of usability evaluation: How many subjects is enough? *Human Factors, 34*(4): 457-468.

West, J., Hall, P., Arredono, V., Berrett, B., Guerra, B. & Farrell, J. (2013). Health behavior theories in diet apps. *Journal of Consumer Health on the Internet, 17*(1): 10-24.

Appendix 6.2. Chapter 6: Stimulus control and eating study

Title: Body Mass Index and Stimulus Control: Results from a Real-World Study of Eating Behaviour

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Abstract

Background: Evidence suggests that decisions about when, what, and how much to eat can be influenced by external (e.g. location) and internal (e.g. mood) cues. Such information is crucial for development of tailored interventions. Although the relationship between cue-reactivity (i.e., stimulus control) and obesity is debated, there is some evidence to suggest individuals with higher BMIs are more driven by cues to eating than individuals with lower BMIs. This study investigates the influence of stimulus control on real-world food intake, and whether the degree of stimulus control differs by BMI.

Method: 73 participants (n = 34 BMI < 24.9, n = 39 BMI > 24.9) recorded their food intake for 14 days using Ecological Momentary Assessment.

Participants also responded to 4-5 randomly-timed assessments per day. Known external and internal eating cues were assessed during both assessment types. Within-person logistic regression analyses were used to predict eating vs. non-eating occasions from a set of external (e.g. location) and internal (e.g. affect) cues.

Findings: Results were consistent with the hypothesis that eating patterns were influenced by stimulus control: food availability, affect, time of day, and location were significant predictors of eating (vs. non-eating) instances (AUC-ROC=.58-.69, all p's<.001). Individuals with high BMIs were more guided by the presence of food outlets compared to normal-weight individuals (t(68.44) = 2.88, p = 0.005, d = 0.65).

Discussion: Results support the notion of stimulus control shapes eating decisions. Additionally, differences in levels of stimulus control between participants in the healthy weight range compared to those with a high BMI suggest that interventions aimed at modifying eating behaviour will be more beneficial if they are both tailored to the individual and take environmental influences on eating behaviour into consideration.

Keywords: Ecological momentary assessment, Eating, BMI, Stimulus control, Environmental cues

Introduction

Current figures estimate that more than two thirds of the Australian adult population are overweight and/or obese, with the number of adults categorised as overweight and/or obese rapidly growing in the last two decades (Australian Bureau of Statistics [ABS], 2018). Overweight and obesity are associated with an increase of a number of chronic diseases such as cardiovascular disease and type 2 diabetes, costing AUD$58 billion annually (ABS, 2018; Sainsbury, Hendy, Magnusson, & Colagiuri, 2018). In order to address what is now considered a growing public health concern (World Health Organisation, 2018), it is crucial to understand factors contributing to weight gain.

Although obesity results from a complex combination of biological, behavioural, and environmental factors, at the simplest level, obesity is the result of an imbalance between energy intake and energy expenditure (Butland et al., 2007). Importantly, it has been argued that increase of caloric intake alone— regardless of changes to physical activity levels— is enough to account for the increase in population weight (Swinburn, Sacks, & Ravussin, 2009). The majority of caloric intake occurs for reasons other than restoring energy balance (aka, “hunger”; Brownell & Horgen, 2004). Individuals are prompted to eat by external cues (such as the sight or smell of food through either food advertising or seeing others eat) or internal cues (such as mood) rather than a physiological need to eat (Havermans, 2013). The relationship between food-related cues and eating can be conceptualized as stimulus control (Weingarten, 1985). It has been theorized that stimulus control influences eating behaviour through an automatic processing of (previously conditioned) food-related cues in one’s environment (Bilman, van Kleef, & van Trijp, 2017). Such cues are then misinterpreted as signs of energy depletion (i.e., biological hunger), motivating us to respond accordingly (Lowe & Butryn, 2007). Stimulus control is especially relevant in terms of understanding the intake of highly palatable, energy-dense foods, as such food items are seen as rewarding and therefore act as a 'motivational magnet' driving subsequent behaviour (Berridge, 2004).

Stimulus control is commonly examined in laboratory settings. For example, in a simulated fast-food laboratory, presenting participants with a range fast-food cues (such as smell of French fries cooking and images of high-caloric food items) resulted in a significant increase in caloric consumption compared to caloric consumption in a neutral environment (Joyner, Kim, & Gearhardt, 2017). Simillarly, Prinsen, de Ridder and de Vet (2013) found that participants were ~3 times more likely to consume a chocolate when the bowl of chocolates was surrounded by discarded chocolate wrappers compared to no wrappers, suggesting that even cues regarding others' eating behaviour can influence one's food choice. Importantly, experimental work using cognitive tasks and/or neuroscientific methods (such as fMRI, EEG or eye tracking) has found that individuals with obesity are more attentive to eating-related cues (Hendrikse et al., 2015), and in turn consume higher amounts of palatable foods compared to healthy-weight participants (Kakoschke, Kemps, & Tiggemann, 2015; Werthmann et al., 2011). Taken together, these findings suggest that responses to food-related cues may be predictive of food intake and could potentially differentiate the eating patterns of individuals with obesity compared to those in the healthy weight range. Given that today's food environment provides individuals with many highly-palatable food cues which are both the most aggressively advertised and easily accessible compared to healthier options (Hoek & Gendall, 2006), such findings are particularly problematic.

A key concern with laboratory-based studies is their ecological validity; the degree to which they model actual real-world behaviour. A way to overcome this is to triangulate findings from lab studies with those from studies of real-world eating. While observational, Ecological Momentary Assessment (EMA; Shiffman, Stone, & Hufford,

2008) methods are particularly useful for studying eating as they allow individuals to record their food intake in real-time, in participants' natural environments (Ferguson & Shiffman, 2011). Importantly, using EMA methods to examine cue-related eating provides real-world validation of laboratory findings. Such studies have provided support for the relationship between stimulus control and eating (e.g., Elliston, Ferguson, Schüz, & Schüz, 2016; Schüz, Bower, & Ferguson, 2015). For example, seeing others eat increased the odds of consuming a high-energy snack by 39% (Elliston et al., 2016). Moreover, Schüz, Revell, Hills, Schüz, and Ferguson (2017) found that as Body Mass Index (BMI) increased, the odds of consuming a snack when seeing someone else eat also increased. Such findings suggest that one's BMI may influence how one responds to food-related cues. However, Schüz et al. (2017)'s findings are limited in that only the effects of social cues surrounding eating were examined. Given that that cues to eating are likely to be idiosyncratic— that is, that people differ in the type of cues that are most likely to prompt them to eat— present study aims to examine the relationship between BMI and a broader range of previously established cues.

Method

The present study used EMA methods to study the eating patterns of a community sample. For the duration of two weeks, participants logged all instances of eating and drinking into a smartphone running study-specific software (HBART; see: http://www.utas.edu.au/health/research/groups/behavioural-and-situational-research-group-bsrg/hbart) as well as responding to randomly-timed assessments throughout the day. The study was approved by the Tasmanian Social Sciences Human Research Ethics Committee (H0017015).

Participants

Seventy-nine individuals were recruited through social media (Frandsen, Walters, & Ferguson, 2013) and flyers seeking individuals interested in participating in a study examining eating patterns. Eligibility criteria included being aged 18-65, having no history of eating disorders, not currently dieting, and having a BMI >18.5. Five participants were excluded due to screening scores exceeding 20 on the Eating Attitudes Test (EAT-26; Garner & Garfinkel, 1979), indicating concerns regarding body weight, shape and/or eating were present. The final sample consisted of 73 participants (71.23% female), with a mean age of 33.61 (SD = 11.95), and BMI ranging between 18.6 and 40.2 (M = 26.65, SD = 5.55). By design, approximately half (46.58%) of the sample had a BMI in the healthy-weight range (HWR; BMI range:18.5 – 24.5, n = 34).

Procedure

The procedure and instruments used were modelled on earlier protocols (Elliston et al., 2016; Schüz et al., 2015). Interested individuals were invited for an initial meeting (approx. 45 minutes) during which they provided consent, completed a baseline questionnaire, and had their height and weight measured for BMI calculations. Participants were then provided with a smartphone running EMA software along with individualized training on how to use the device.

For 14 consecutive days, participants were asked to carry the EMA device during waking hours and log every instance of their eating and drinking (with the exception of water consumption). Participants were asked to log food and drink immediately prior to their consumption. When logging eating instances, participants were prompted to choose between reporting a meal (breakfast, lunch, or dinner), or a snack; defined as any between meal food intake.

In addition to logging instances of eating and drinking, participants were asked to respond to randomly-timed “prompts” (four to five times a day) assessing participants’ location, social setting, current activity and affective state (discussed in greater detail below). These randomly-timed prompts allow for comparisons of the intensity and the presence of cues between food logs and instances of non-eating. After approximately two days of monitoring participants were asked to return to the university for a short (10-15 minutes) visit during which their compliance with the monitoring procedure was assessed and any additional re-training was administered. During a third visit at the end of monitoring, participants returned the EMA device and were reimbursed AUD$60 for their participation.

Measurement instruments

Assessment of internal cues focused on mood, which has previously been associated with increased food intake (Singh, 2014). During both food/drink logs and random prompts, mood was assessed across three dimensions: *valence* (items: 'good', 'bad'), *energetic arousal* (items: 'awake', 'tired') and *tense arousal,* which included items 'nervous' and 'calm'. Items were rated on scale of 1 (*not at all*) to 5 (*extremely*), with higher scores indicating higher positive affect, higher energetic and tense arousal (Wenzel, Kubiak, & Conner, 2014).

Assessment of external cues included asking participants to indicate in a yes (1)/no (0) format; whether*, when they decided to eat,* were there people eating (i.e., in my group, in sight), was food available (i.e., confectionary, savory, cakes), whether they were "with others" (i.e., romantic partner, co-workers, family), current location (i.e., workplace, restaurant, vehicle), and, whether or not there were any food outlets in sight. Such assessment has previously shown external validity in predicting eating behaviour (Elliston et al., 2016; Schüz et al., 2015; Schüz, Schüz, & Ferguson, 2015). Additionally, participants were asked "Do you think the people with you would approve or disapprove of you eating right now", which was answered on a scale of 1 (*strongly disapprove*) to 5 (*strongly approve*) to gauge the social acceptability of eating in participants' environments (East et al., 2018).

Analytical procedure

The 73 participants completed 1080 participant-days of monitoring. In line with previous EMA studies (Elliston et al., 2016; Schüz et al., 2015), days with poor compliance (defined as answering <50% of random prompts) were excluded from the final analysis (n = 145 days), leaving 935 participant-days of data eligible for analysis (M= 15.22 days per person, SD = 1.77). During this time, a total of 2916 random prompts were issued, with each participant receiving an average of 3.12 prompts (SD = .80) per day, of which 86.61% (n = 2493) were completed and thus available for analysis. Participants also reported a total of 2102 meals (M = 2.32 per participant day) and 1235 snacks (M = 1.37 per participant day) in real time.

The primary analysis involved a two-step analytical procedure and mirrored methods used in previous studies of real-world stimulus control (Ferguson, Frandsen, Dunbar, & Shiffman, 2015). Firstly, eight separate univariate logistic regression models were run separately for each participant. Eating (yes/no) was the outcome variable for all models, with the predictors groups into five stimulus control domains: (i) affect / mood, (ii) time of day, (iii) location, (iv) food outlet presence, and (v) foods availability. The degree to which each model could differentiate between eating (i.e., meal / snack reports) and non-eating (i.e., random prompt reports) was assessed using the area under the curve – receiver operating characteristic (AUC-ROC) scores. AUC-ROC scores range from 0.5 (random chance) to 1 (perfect prediction). Next (step two), to address the key study aim of examining the relationship between BMI and stimulus control domains, mean AUC-ROC scores for each domain were compared between the high BMI and HWR groups using t-tests. The proposed analytic plan was pre-registered (https://osf.io/b9t2h) prior to the commencement of data analysis.

Results

Figure 1 shows the mean AUC-ROC scores for all domains assessing internal and external cues for both HWR and high BMI groups. BMI grouping aside, one sample

t-tests demonstrate that the AUC-ROC values for all analysed domains were significantly higher than 0.50 (all p values <.001), indicating that all domain models were able to differentiate between instances of eating and non-eating.

The high BMI group had higher AUC-ROC scores for almost all domains, however, only the domain of food outlets presence was statistically significant, $t(68.44) = 2.88$, $p = 0.005$, $d = 0.65$. As each participant's history of eating is unique, it follows that the degree to which eating will be associated with specific cues will be idiosyncratic. As such, we also conducted an exploratory analysis where we first identified each participant's highest AUC-ROC value (based on the results from the five domain models) and then compared the mean values for HWR and high BMI groups. The two groups did not differ (.72 vs .71; $t(71.95) = 0.47$, $p = 0.644$, $d = 0.11$).

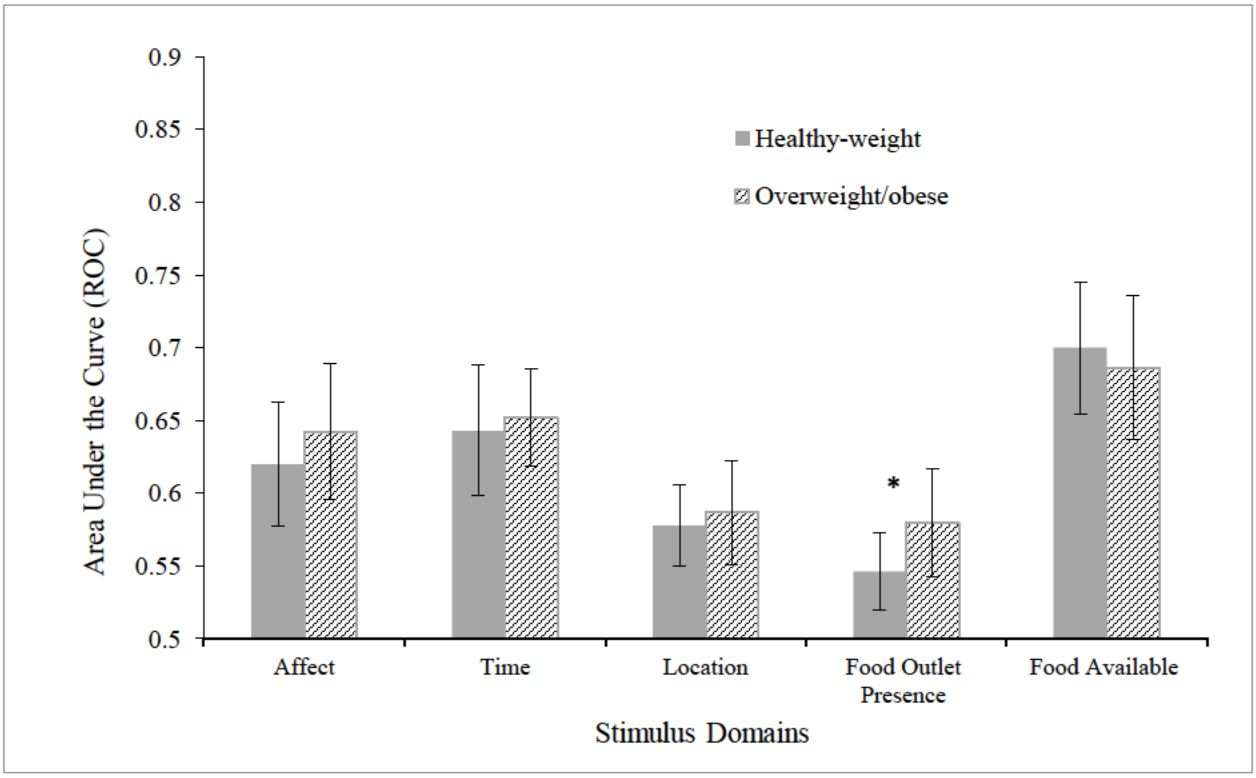

Figure 1. Mean AUC-ROC by BMI for domains of context. The AUC-ROC value represents the probability of accurately differentiating between eating and non-eating events. A value of 0.50 suggests there to be no association between eating events and

the domain, whereas a value of 1.0 would indicate perfect prediction. BMI differences were tested between groups using *t*-tests (where * indicates $p < .05$). Error bars represent 95% confidence intervals of the AUC-ROC.

Discussion

The present study examined BMI differences in stimulus control and eating behaviour over the duration of ~14 days in a community sample through the use of EMA. All domains assessing internal and external cues to eating could accurately differentiate between eating and non-eating instances, providing further support for the role of stimulus control in influencing eating behaviour (Elliston et al., 2016; Schüz et al., 2015; Schüz, Papadakis, & Ferguson, 2018). Having food easily available was one of the strongest predictors of eating which is in line with previous findings (Zenk et al., 2014). Given the definition of "easily available" is quite broad, this could have been interpreted either as food that was made easily available to individuals at their place of work, or, food that was pre-prepared by the individual. Both interpretations are in line with previous research which found that availability of palatable foods in one's environment (e.g., either in a buffet line at a cafeteria or the refrigerator at home) significantly increased the probability of overeating for individuals with a high BMI (Thomas, Doshi, Crosby, & Lowe, 2011).

The present study also found an association between fluctuation in affect and eating behaviour, such that changes in one's mood allowed us to accurately differentiate between eating and non-eating instances 63% percent of the time. The results of this study suggest that emotional arousal in general is associated with increased food intake, which is in line with previous literature (Evers, Adriaanse, de Ridder, & de Witt Huberts, 2013). Although much of the literature around emotion and eating has focused on negative affect both in labaratory (i.e., Frayn, Sears, & von Ranson, 2016; Hepworth et al., 2010) and observational studies (Cleobury & Tapper, 2014; Raspopow, Matheson, Abizaid, & Anisman, 2013), it has been argued that positive emotions may play an equally important role in food intake (Bongers, Jansen, Havermans, Roefs, & Nederkoorn, 2013). As such, more work is required to better understand whether emotional arousal or valance play the largest role in food intake. Future studies should consider measuring affect immediately prior and post consumption in order to clarify this relationship.

In addition to food availability and negative affect, both the time of day and one's location was associated with food intake, which is in line with previous literature (Cleobury & Tapper, 2014; Myhre, Løken, Wandel, & Andersen, 2015). The presence of food outlets in predicting food intake had the weakest discriminative ability in differentiating between eating and non-eating instances. Whilst this is contrary to previous findings (i.e., Elliston et al., 2017), it is important to note that the present study did not differentiate between snacks and meals. In Elliston and colleagues' study, snacks were particularity influenced by the presence of food outlets.

Regarding BMI related differences in stimulus control, we found some evidence in support of our hypothesis. Individuals with high BMI were more likely to be cued to eat when in proximity to food outlets in comparison to those in the HWR. This suggests that environmental factors such as sight and/or smell of food should be taken into consideration when designing weight-loss interventions. Importantly, as can be seen in *Figure 1*, the pattern of results suggests that in general, individuals with a high BMI experience higher levels of stimulus control than those in the HWR. It is possible that the present study did not have adequate power to detect the magnitude of the effect required to see significant differences between the two groups. It would be beneficial to re-examine this relationship with a larger sample. Additionally, dichotomising the sample into HWR or high BMI groups based on a single BMI unit may have reduced some of the effects. Future research would benefit from comparing individuals in the HWR to those with obesity (BMI range >30), as this categorisation may highlight any possible cue-related eating differences.

Strengths and limitations

To our knowledge, this is the first study to examine eating patterns amongst both HWR and high BMI participants across a number of stimulus control domains using EMA methods. Whilst observational methods such as EMA are not without flaws, by using this approach we are able to offer a different angle to previously reported laboratory findings on cue-related eating. EMA methods allow for real-time assessment of eating behaviour and any consumption related cognitions, minimizing biases associated with recall. Additionally, real-time assessments of eating may be able to overcome the shortcomings of other traditional measures of eating behaviour. For example, food frequency questionnaires, food diaries and clinical interviews have previously been found to be susceptible to underreporting of snacks (Heitmann & Lissner, 1995). Moreover, the combination of event logs and random prompts allows for comparisons between the known predictors of eating behaviour which participants experienced during eating with those experienced during random prompts. Such comparison allows for investigation of determinants of eating in greater detail compared to using recall methods or examining assumed antecedents during eating instances alone (Shiffman, Stone, & Hufford, 2008). Although external cues on eating behaviour have been previously examined (Schüz, Bowe, & Ferguson, 2015; Schüz et al., 2017), the present study was the first to investigate the effect of the three most commonly reported cues (location, food availability and food outlet presence) simultaneously.

Despite these strengths, the present findings must be taken into consideration with key limitations. The present study looked at overall food intake instead of looking at discretionary food (i.e. snack) consumption. Research suggests that discretionary food intake is particularly influenced by stimulus control (e.g., Elliston et al., 2016; O'Connor et al., 2008). Nevertheless, the present study provides useful information on food-related cues which are likely to also influence discretionary food intake. Additionally, the present study did not track changes in participants' location. Having little variation in location may explain why the domain of location was not highly discriminative in differentiating between eating and non-eating instances. In order to better understand the influence of location on eating behaviour, future studies could benefit from using Global Positioning System (GPS) to capture individuals' daily travel patterns (Chaix et al., 2012; Zenk et al., 2011).

In order to minimize participant burden, the present study focused on a limited selection of stimulus control domains. As such, situational predictors of eating behaviour such as daily hassles (O'Connor et al., 2008) and state hunger (Witt, Raggio, Butryn, & Lowe, 2014) were not assessed. Additionally, measures of inhibitory control which have been associated with poor food choices (Dohle, Diel, & Hofmann, 2017) were not included in the present study. Future studies would benefit from combining laboratory-based and real-world measurements of food cue-responsiveness to understand the mechanisms underpinning the relationship between stimulus control and food intake.

Implications and conclusions

Despite these limitations, the present study has important implications for both theory and intervention development for adults with overweight and obesity. The present study was able to provide real-time, real-world evidence to previously established laboratory findings regarding differences in BMI-related cue-responsiveness (Hendrikse et al., 2015; Kemps & Tiggemann, 2015). Whilst we did not directly compare the individual models, availability of food appeared to be the strongest predictor of food intake. This suggests that for individuals wanting to make healthier food choices, meal and snack preparation (i.e., having healthy snacks prepared and available) may facilitate healthy food choices by providing alternative options to what is readily available in their place of work / study (Sciamanna et al., 2011). Additionally, the finding that food outlet presence has a greater influence on individuals with a high BMI compared to those within the HWR suggests that this population could benefit from not only meal planning, but also avoiding the presence of food outlets, particularly areas with a high density of fast food outlets. This is in line with previous studies which have found an association between neighbourhood typologies and obesity (Hobbs et al., 2018).

To conclude, the present study demonstrates the influence of eating-related cues on eating behaviour. Specifically, differences in levels of stimulus control between HWR and high BMI participants suggest that interventions aimed at modifying eating behaviour may have greater success if these are both tailored to the individual and take environmental influences on eating behaviour into consideration.

References

Australian Bureau of Statistics [ABS]. (2018). *4364.0.55.001 - National Health Survey: First Results, 2017-18* Retrieved from http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/4364.0.55.001~2014-15~Main%20Features~Overweight%20and%20obesity~22

Berridge, K. C. (2004). Motivation concepts in behavioral neuroscience. *Physiology & Behavior, 81*(2), 179-209.

Bilman, E., van Kleef, E., & van Trijp, H. (2017). External cues challenging the internal appetite control system—overview and practical implications. *Critical reviews in food science and nutrition, 57*(13), 2825-2834.

Bongers, P., Jansen, A., Havermans, R., Roefs, A., & Nederkoorn, C. (2013). Happy eating. The underestimated role of overeating in a positive mood. *Appetite, 67*, 74-80.

Brownell, K. D., & Horgen, K. B. (2004). *Food fight: The inside story of the food industry, America's obesity crisis, and what we can do about it*: Contemporary books Chicago, IL.

Butland, B., Jebb, S., Kopelman, P., McPherson, K., Thomas, S., Mardell, J., & Parry, V. (2007). *Tackling obesities: future choices-project report* (Vol. 10): Citeseer.

Chaix, B., Meline, J., Duncan, S., Merrien, C., Karusisi, N., Perchoux, C., . . . Kestens, Y. (2013). GPS tracking in neighborhood and health studies: a step forward for environmental exposure assessment, a step backward for causal inference? Health Place, 21, 46-51. doi:10.1016/j.healthplace.2013.01.003

Cleobury, L., & Tapper, K. (2014). Reasons for eating ‘unhealthy’snacks in overweight and obese males and females. *Journal of Human Nutrition and Dietetics, 27*(4), 333-341.

Dohle, S., Diel, K., & Hofmann, W. (2017). Executive functions and the self-regulation of eating behavior: a review. *Appetite*.

East, K., Hitchman, S. C., Bakolis, I., Williams, S., Cheeseman, H., Arnott, D., & McNeill, A. (2018). The association between smoking and electronic cigarette use in a cohort of young people. *Journal of Adolescent Health, 62*(5), 539-547.

Elliston, K. G., Ferguson, S. G., Schüz, N., & Schüz, B. (2016). Situational cues and momentary food environment predict everyday eating behavior in adults with overweight and obesity. *Health Psychol, 36*(4), 337-345. doi:10.1037/hea0000439

Evers, C., Adriaanse, M., de Ridder, D. T., & de Witt Huberts, J. C. (2013). Good mood food. Positive emotion as a neglected trigger for food intake. *Appetite, 68*, 1-7.

Ferguson, S. G., Frandsen, M., Dunbar, M. S., & Shiffman, S. (2015). Gender and stimulus control of smoking behavior. *Nicotine Tob Res, 17*(4), 431-437. doi:10.1093/ntr/ntu195

Ferguson, S. G., & Shiffman, S. (2011). Using the methods of ecological momentary assessment in substance dependence research—Smoking cessation as a case study. *Substance use & misuse, 46*(1), 87-95.

Frandsen, M., Walters, J., & Ferguson, S. G. (2013). Exploring the Viability of Using Online Social Media Advertising as a Recruitment Method for Smoking Cessation Clinical Trials. *Nicotine & Tobacco Research, 16*(2), 247-251. doi:10.1093/ntr/ntt157

Frayn, M., Sears, C. R., & von Ranson, K. M. (2016). A sad mood increases attention to unhealthy food images in women with food addiction. *Appetite, 100*, 55-63.

Garner, D. M., & Garfinkel, P. E. (1979). The Eating Attitudes Test: An index of the symptoms of anorexia nervosa. *Psychological medicine, 9*(2), 273-279.

Havermans, R. C. (2013). Pavlovian craving and overeating: a conditioned incentive model. *Current Obesity Reports, 2*(2), 165-170.

HBART. (2012). *Health behaviour assessment in real time.* Retrieved from http://www.utas.edu.au/health/research/groups/behavioural-and-situational-research-group-bsrg/hbart

Heitmann, B. L., & Lissner, L. (1995). Dietary underreporting by obese individuals--is it specific or non-specific? *Bmj, 311*(7011), 986-989.

Hendrikse, J. J., Cachia, R. L., Kothe, E. J., McPhie, S., Skouteris, H., & Hayden, M. J. (2015). Attentional biases for food cues in overweight and individuals with obesity: a systematic review of the literature. *Obes Rev, 16*(5), 424-432. doi:10.1111/obr.12265

Hepworth, R., Mogg, K., Brignell, C., & Bradley, B. P. (2010). Negative mood increases selective attention to food cues and subjective appetite. *Appetite, 54*(1), 134-142. doi:10.1016/j.appet.2009.09.019.

Hoek, J., & Gendall, P. (2006). Advertising and obesity: a behavioral perspective. *Journal of Health Communication, 11*(4), 409-423.

Hobbs, M., Griffiths, C., Green, M., Jordan, H., Saunders, J., & McKenna, J. (2018). Neighbourhood typologies and associations with body mass index and obesity: A cross-sectional study. *Preventive medicine, 111*, 351-357.

Joyner, M. A., Kim, S., & Gearhardt, A. N. (2017). Investigating an incentive-sensitization model of eating behavior: impact of a simulated fast-food laboratory. *Clinical Psychological Science, 5*(6), 1014-1026.

Kakoschke, N., Kemps, E., & Tiggemann, M. (2015). Combined effects of cognitive bias for food cues and poor inhibitory control on unhealthy food intake. *Appetite, 87*, 358-364.

Kemps, E., & Tiggemann, M. (2015). Approach bias for food cues in obese individuals. *Psychology & Health, 30*(3), 370-380.

Lowe, M. R., & Butryn, M. L. (2007). Hedonic hunger: a new dimension of appetite? *Physiology & Behavior, 91*(4), 432-439.

Myhre, J. B., Løken, E. B., Wandel, M., & Andersen, L. F. (2015). The contribution of snacks to dietary intake and their association with eating location among Norwegian adults–results from a cross-sectional dietary survey. *BMC public health, 15*(1), 369.

O'Connor, D. B., Jones, F., Conner, M., McMillan, B., & Ferguson, E. (2008). Effects of daily hassles and eating style on eating behavior. *Health Psychology, 27*(1S), S20.

Prinsen, S., de Ridder, D. T., & de Vet, E. (2013). Eating by example. Effects of environmental cues on dietary decisions. *Appetite, 70*, 1-5.

Sainsbury, E., Hendy, C., Magnusson, R., & Colagiuri, S. (2018). Public support for government regulatory interventions for overweight and obesity in Australia. *BMC public health, 18*(1), 513.

Schüz, B., Bower, J., & Ferguson, S. G. (2015). Stimulus control and affect in dietary behaviours. An intensive longitudinal study. *Appetite, 87*, 310-317. doi:10.1016/j.appet.2015.01.002

Schüz, B., Papadakis, T., & Ferguson, S. G. (2018). Situation-specific social norms as mediators of social influence on snacking. *Health Psychol, 37*(2), 153-159. doi:10.1037/hea0000568

Schüz, B., Revell, S., Hills, A. P., Schüz, N., & Ferguson, S. G. (2017). Higher BMI is associated with stronger effects of social cues on everyday snacking behaviour. *Appetite, 114*, 1-5. doi:10.1016/j.appet.2017.03.012

Schüz, B., Schüz, N., & Ferguson, S. G. (2015). It's the power of food: individual differences in food cue responsiveness and snacking in everyday life. *Int J Behav Nutr Phys Act, 12*, 149. doi:10.1186/s12966-015-0312-3

Sciamanna, C. N., Kiernan, M., Rolls, B. J., Boan, J., Stuckey, H., Kephart, D., . . . Loken, E. (2011). Practices associated with weight loss versus weight-loss maintenance: results of a national survey. *American journal of preventive medicine, 41*(2), 159-166.

Shiffman, S., Stone, A. A., & Hufford, M. R. (2008). Ecological momentary assessment. *Annu. Rev. Clin. Psychol., 4*, 1-32.

Singh, M. (2014). Mood, food, and obesity. *Frontiers in psychology, 5*, 925.

Swinburn, B., Sacks, G., & Ravussin, E. (2009). Increased food energy supply is more than sufficient to explain the US epidemic of obesity. *The American journal of clinical nutrition*, *90*(6), 1453-1456.

Thomas, J. G., Doshi, S., Crosby, R. D., & Lowe, M. R. (2011). Ecological momentary assessment of obesogenic eating behavior: combining person-specific and environmental predictors. *Obesity, 19*(8), 1574-1579.

Weingarten, H. P. (1985). Stimulus control of eating: Implications for a two-factor theory of hunger. *Appetite, 6*(4), 387-401.

Wenzel, M., Kubiak, T., & Conner, T. S. (2014). Positive affect and self-control: Attention to self-control demands mediates the influence of positive affect on consecutive self-control. *Cognition & emotion, 28*(4), 747-755.

Werthmann, J., Roefs, A., Nederkoorn, C., Mogg, K., Bradley, B. P., & Jansen, A. (2011). Can (not) take my eyes off it: attention bias for food in overweight participants. *Health Psychology, 30*(5), 561.

Witt, A. A., Raggio, G. A., Butryn, M. L., & Lowe, M. R. (2014). Do hunger and exposure to food affect scores on a measure of hedonic hunger? An experimental study. *Appetite, 74*, 1-5.

World Health Organisation. (2018). *Obesity and overweight*. Retrieved from http://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight

Zenk, S. N., Horoi, I., McDonald, A., Corte, C., Riley, B., & Odoms-Young, A. M. (2014). Ecological momentary assessment of environmental and personal factors and snack food intake in African American women. *Appetite, 83*, 333-341. doi:10.1016/j.appet.2014.09.008

Zenk, S. N., Schulz, A. J., Matthews, S. A., Odoms-Young, A., Wilbur, J., Wegrzyn, L., . . . Stokes, C. (2011). Activity space environment and dietary and physical activity behaviors: a pilot study. Health Place, 17(5), 1150-1161. doi:10.1016/j.healthplace.2011.05.001